


## ORIGINAL RESEARCH

# Early experience with feasibility of balloon sinus dilation in complicated pediatric acute frontal rhinosinusitis

Sarah K. Maurrasse MD<sup>1</sup> | Tiffany P. Hwa MD<sup>1</sup>  | Erik Waldman MD<sup>2</sup> |  
Ashutosh Kacker MBBS<sup>1</sup> | Aaron N. Pearlman MD<sup>1</sup><sup>1</sup>Department of Otolaryngology–Head and Neck Surgery, Weill Cornell Medical College, New York, New York<sup>2</sup>Department of Otolaryngology–Head and Neck Surgery, Yale School of Medicine, New Haven, Connecticut**Correspondence**Aaron N. Pearlman, Department of Otolaryngology–Head and Neck Surgery, 1305 York Avenue, 5th Floor, New York, NY 10021.  
Email: anp2022@med.cornell.edu**Abstract****Background/Objective:** Complicated acute rhinosinusitis in the pediatric population is an uncommon problem that may affect the orbit or brain and is life-threatening. This condition requires surgical intervention with endoscopic sinus surgery for source control, and prior studies have demonstrated the safety of balloon sinuplasty in chronic frontal sinusitis.**Methods/Results:** We present our approach with a balloon sinus dilation hybrid procedure to resolve four distinct types of complicated acute frontal sinusitis in pediatric patients, including intracranial manifestations, intraorbital complications, and recurrent disease. All four patients were able to be managed operatively with frontal balloon sinuplasty.**Conclusions:** Prior efficacy has been demonstrated for chronic frontal sinusitis in the pediatric population. We demonstrate that frontal balloon sinuplasty is also feasible in the proper clinical setting for acute frontal sinusitis, even in the presence of regional complications or recurrent disease.**Level of Evidence:** 4**KEYWORDS**

balloon dilation, balloon sinuplasty, endoscopic sinus surgery, frontal sinusitis, pediatric ARS

## 1 | INTRODUCTION

Complicated acute rhinosinusitis (ARS) in the pediatric population is an uncommon problem that is potentially life-threatening. Facial cellulitis, pre- and postseptal cellulitis of the orbit, osteomyelitis, meningitis, cavernous sinus thrombosis, and abscesses of the orbit, facial soft tissue, epidural space, and brain are known complications of ARS.

Complicated frontal ARS warrants prompt intervention, but the proper modality remains a topic of debate. Following immediate intravenous (IV) antibiotics, the traditional options for surgical intervention include trephination, craniotomy, or endoscopic sinus surgery (ESS) to address the affected frontal sinus. However, it may be possible to

address the frontal recess using balloon sinus dilation with limited traditional ESS, a hybrid procedure that can limit the amount of traditional dissection necessary.

In the pediatric population, data are limited regarding pediatric patients with complicated acute frontal rhinosinusitis. Multiple academic and professional societies, including the American Academy of Otolaryngology–Head and Neck Surgery, the International Consensus Statement on Allergy and Rhinology (ICAR), and the European Academy of Allergy and Clinical Immunology (EAACI), have released formal consensus statements or position papers regarding the management of pediatric chronic rhinosinusitis (CRS).<sup>1–3</sup> The European Position Paper on Rhinosinusitis and Nasal Polyps advocates for ESS as an

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**TABLE 1** Clinical summary

	Case 1	Case 2	Case 3	Case 4
Age (y)	10	13	10	11
Gender	Male	Male	Male	Male
Laterality	Left	Right	Left	Left
Complication of frontal ARS	Recurrent forehead swelling	Eye pain, brow abscess	Frontal dural enhancement	Recurrent CRS, revision surgery
Additional ESS	Limited anterior ethmoid, contralateral maxillary	Maxillary, total ethmoid	Anterior ethmoid	Contralateral maxillary
Length of hospital stay	Outpatient	6 d	3 d	3 d
Frontal sinus patency at follow-up	Patent (endoscopy)	Not assessed	Lost to follow-up after discharge	Patent (endoscopy)

Abbreviations: ARS, acute rhinosinusitis; CRS, chronic rhinosinusitis; ESS, endoscopic sinus surgery.

indication in pediatric patients with orbital abscess, intracranial complications, antrochoanal polyp, mucocoeles or mucopyocoeles, fungal rhinosinusitis, and complete nasal obstruction in cystic fibrosis.<sup>3</sup> The American Academy of Pediatrics also advocates for surgical intervention with ESS in the presence of progressive signs or symptoms, orbital compromise, or altered mental status.<sup>4</sup> Beyond this, there is limited guidance available for practitioners who encounter acute frontal rhinosinusitis in the challenging anatomy of our pediatric patients.

In this study, we aim to show the feasibility of using balloon sinus dilation in the management of complicated pediatric ARS. A clinical summary of all four cases is provided in Table 1.

## 2 | CASE PRESENTATIONS

### 2.1 | Recurrent left forehead swelling

A 10-year-old male with no significant past medical history presents with recurrent left forehead swelling associated with headache and fever. The swelling would resolve with oral antibiotics, then recur. He underwent computed tomography (CT) and was found to have moderate mucosal inflammation of the left frontal sinus outflow tract (Figure 1A-C), as well as a right atelectatic maxillary sinus with near complete opacification. No obvious dehiscence was identified in the anterior table of the left frontal sinus. The decision was made to proceed to surgery, and the patient underwent left frontal sinus balloon dilation with a limited anterior ethmoidectomy and a right maxillary antrostomy on an outpatient basis. The patient's recurrent forehead swelling resolved and is without recurrence after 3 years. His most recent follow-up also demonstrated patency of the frontal sinus outflow tract on nasal endoscopy.

### 2.2 | Right eye pain and brow abscess

A 13-year-old male with no significant past medical history presents with rapidly progressive swelling over the right eye with pain and

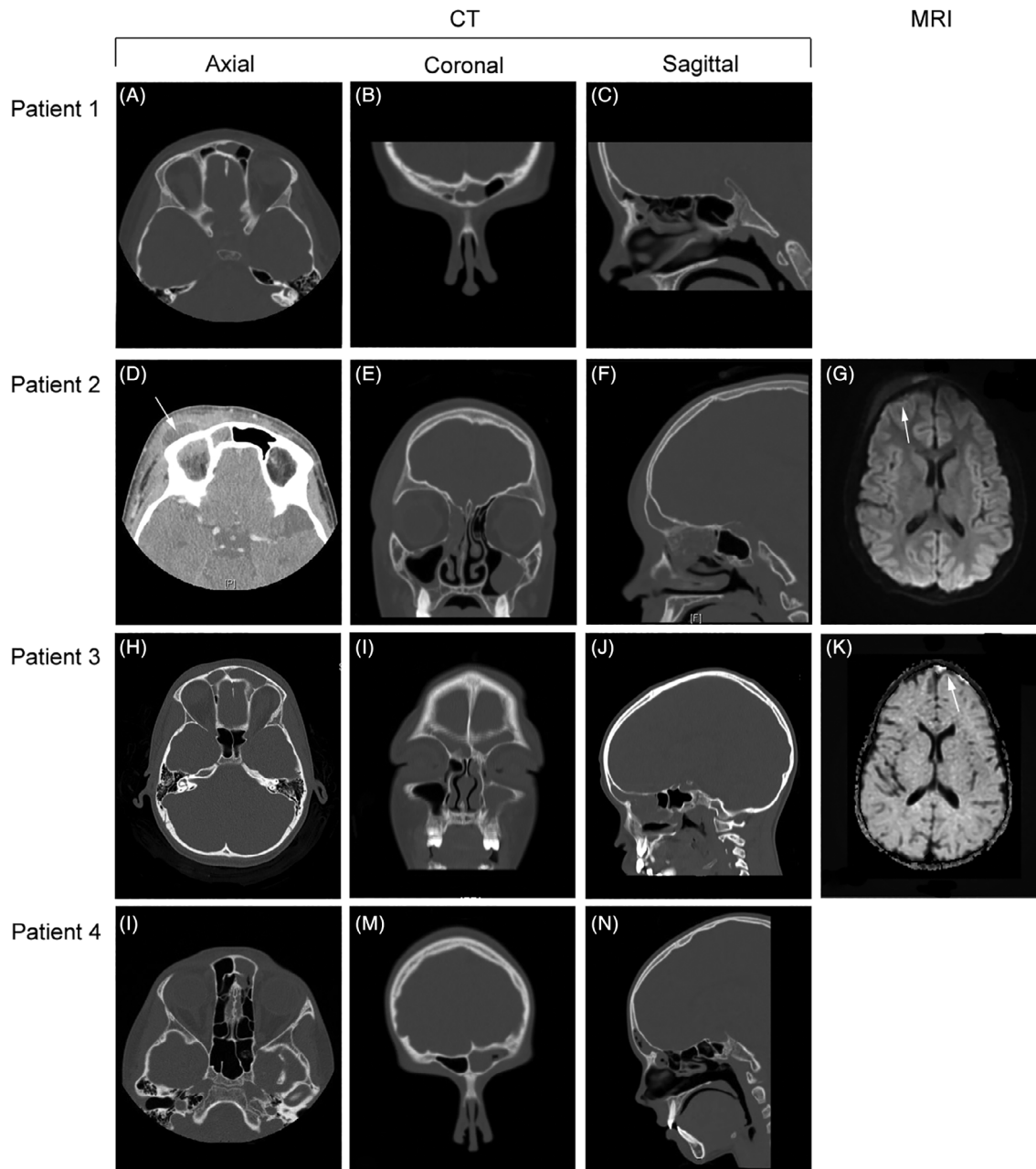
fever. A CT demonstrated complete opacification of the right frontal, anterior and posterior ethmoid, and circumferential thickening of the bilateral maxillary sinuses (Figure 1E,F). It was also notable for an abscess cavity anterior to the right anterior frontal table without violation of the cortex (Figure 1D). A magnetic resonance imaging (MRI) was performed, revealing a small right frontal epidural abscess with adjacent pachymeningitis (Figure 1G). He underwent right ESS, including maxillary antrostomy, total ethmoidectomy and balloon sinus dilation of the frontal sinus, as well as external drainage of the brow abscess. After a 6-day hospital admission, he was treated postoperatively with 6 weeks of IV antibiotics with complete resolution of symptoms and no recurrence at 1 year.

### 2.3 | Dural enhancement

A 10-year-old male who was previously healthy presents with 11 days of rhinorrhea, cough, fevers, bilateral frontal and periorbital edema, and acute onset "staring episodes" concerning for seizures. Nasal endoscopy was notable for pus in the left middle meatus. A CT was performed, demonstrating complete opacification of the left maxillary and ethmoid sinuses, partial involvement of the right anterior ethmoid air cells, and left greater than right frontal sinuses (Figure 1H-J). MRI showed associated left frontal dural reactive inflammatory changes (Figure 1K). The patient underwent drainage with left anterior ethmoidectomy and frontal sinus balloon dilation. There were no intraoperative complications, and the patient developed immediate clinical improvement and was discharged after a 3-day hospital admission with a 3 week course of oral antibiotics. The patient was lost to follow-up after discharge.

### 2.4 | History of CRS with immunodeficiency

An 11-year-old male with a past medical history of common variable immunodeficiency disorder and CRS status post three prior ESSs (first at 5 years of age), though notably without intervention on the frontal



**FIGURE 1** Representative slices from CT and MRI studies. A-C, Axial, coronal, and sagittal CT slices demonstrating left frontal sinus opacification in patient 1. D, CT maxillofacial with contrast showing an abscess (arrow) adjacent to the right anterior frontal table in patient 2. E and F, Coronal and sagittal slices with significant right frontal and ethmoid sinus opacification in patient 2. G, Axial MRI image revealing a small right frontal epidural abscess with adjacent pachymeningitis (arrow) in patient 2. H-J, Axial, coronal, and sagittal CT images showing opacification of the left maxillary, left greater than right ethmoid, and bilateral frontal sinuses in patient 3. K, Axial MRI slice notable for left frontal dural reactive changes in patient 3. L-N, Axial, coronal, and sagittal CT images demonstrating left frontal sinus opacification in patient 4. CT, computed tomography; MRI, magnetic resonance imaging

sinus. The patient presented with severe progressive frontal headaches, eye pain, and facial pain associated with low-grade fever. An MRI was performed as an outpatient, demonstrating left frontal sinusitis and a left maxillary mucous retention cyst and he was referred to the emergency room for admission and urgent ophthalmology evaluation. A CT was performed, showing aerosolized secretions of the ethmoid and sphenoid sinuses, polypoid left maxillary sinus mucosal

thickening, and near complete opacification of the left frontal sinus (Figure 1L-N). The patient underwent a left revision maxillary antrostomy and left frontal balloon sinus dilation. After a 3-day hospital admission, he was restarted on his home regimen of antibiotic sinus rinses with nebulized tobramycin/clindamycin/levofloxacin three times a day and discharged on postoperative day 1. At 2 years' follow-up, the patient reported sustained symptom resolution, with

frontal sinus patent on nasal endoscopy and clear on surveillance imaging with MRI.

### 3 | DISCUSSION

#### 3.1 | Pediatric acute frontal rhinosinusitis

Acute sinusitis is defined as infection of one or more of the paranasal sinuses resulting in mucosal inflammation. The pathogenesis of sinusitis has been suggested as follows: obstruction of the sinus outflow tract, ciliary dysfunction, and thickening of secretions.<sup>5</sup> The development of sinusitis is frequently preceded by a viral upper respiratory infection, which is the most common cause of ostial obstruction in children.<sup>5</sup> Secondary bacterial infection of the sinuses, or acute bacterial sinusitis (ABS), complicates approximately 6% to 8% of viral sinusitis cases.<sup>6</sup>

The presentation of pediatric ABS varies.<sup>7</sup> In cases preceded by a viral upper respiratory infection, persistence of cold symptoms longer than 10 days is the hallmark of the disease.<sup>8</sup> Other patterns include either severe symptoms at the onset of illness—such as high fever for 3 to 4 days and purulent rhinorrhea—or worsening of symptoms after an initial improvement.<sup>8</sup> In children with ARS, having an affected frontal sinus makes the risk of intracranial complications higher. Additionally, adolescent males have been noted to be at an even higher risk.<sup>9</sup>

ABS can lead to various complications involving the orbit, the central nervous system (CNS), or the bone via direct extension or hematogenous spread. Complications frequently arise from the frontal and ethmoid sinuses because the frontal sinuses share venous drainage with the CNS and the ethmoid sinus walls, including the lamina papyracea, are very thin.<sup>1</sup> Orbital complications are the most common and include periorbital cellulitis, subperiosteal abscess, orbital cellulitis, and orbital abscess.<sup>10</sup> CNS involvement can lead to cavernous sinus thrombosis, meningitis, and intracranial, epidural, and subdural abscesses.<sup>11</sup> In addition, spreading infection can lead to osteomyelitis or subperiosteal abscess of the frontal bone. Each of our patients presented with a distinct complication of ARS that could be localized to the ipsilateral frontal sinus, including soft tissue swelling, brow abscess, dural enhancement/pachymeningitis, and recurrent disease with imaging-proven involvement of the frontal sinus.

In the presence of complicated acute frontal rhinosinusitis, we strongly advocate for multimodality therapy involving both intravenous broad-spectrum antibiotic coverage and surgical debridement of sequestered bone with frontal recess dissection and/or dilation of the frontal ostium to allow for adequate drainage of the affected sinus.

#### 3.2 | Approaches to the frontal sinus

Historically, acute sinusitis complicated by medial subperiosteal and orbital abscesses were drained via an open external approach using a Lynch incision in combination with an external ethmoidectomy.<sup>12</sup> Currently, ESS is the main surgical technique used to treat acute sinusitis

requiring surgical intervention. Pediatric functional endoscopic sinus surgery (FESS) generally includes uncinectomy, maxillary antrostomy, and/or ethmoidectomy since the sphenoid and frontal sinuses are less developed.<sup>13</sup> However, sphenoid sinusotomy, frontal sinusotomy, opening of the lamina papyracea, and/or a more radical approach may be necessary depending on the extent of the disease.<sup>10</sup>

Surgical intervention is also indicated for CRS patients who fail medical therapy. Common surgical techniques for pediatric CRS include adenoidectomy—which addresses nasopharyngeal obstruction and a source of bacteria—and FESS. In the context of chronic sinusitis, FESS is successful in approximately three-fourths of cases in both children and adults.<sup>10</sup>

When operative approach to the frontal sinus was necessitated prior to the advent of frontal balloon sinus dilation, options for management included endoscopic frontal sinusotomy including all three Draf approaches, frontal sinus trephination, bicoronal approaches to the frontal sinus with cranialization or obliteration. A thorough review in the adult population by Weber et al of outcomes in 635 cases of endoscopic frontal sinus surgery reported success ranging from 79% to 99.3% for all Draf approaches, with a rate of occlusive synechia or scarring of the neo-ostium ranging from 6.7% to 30% in type II sinusotomies and 7% to 18.8% of type III sinusotomies.<sup>14</sup> The overall complication rate for an osteoplastic oblitative frontal sinusotomy was 18% including 3% acute postoperative infections, 3% recurrent CRS, 6% persistent pain, and 1% persistent neuralgia.<sup>14</sup>

#### 3.3 | Frontal balloon sinus dilation

Balloon sinus dilation, which was first introduced in 2005, is a technique commonly utilized in the treatment of adult CRS. Currently, balloon sinus dilation results have only been reported for CRS and balloon sinus dilation is only approved for use in chronic disease. The efficacy of balloon sinus dilation in adults with chronic frontal, sphenoid, and maxillary sinus disease is reported to be on par with ESS, if not better.<sup>15</sup> Levine et al reviewed balloon catheter instrumentation in over 1000 adult patients across 27 practices and found that balloon catheter dilation is safe and effective while leading to improved quality of life measures, with complication, revision, and symptom improvement rates comparable to standard ESS.<sup>16</sup> Hybrid ESS with balloon has also been demonstrated to result in greater permeability of the frontal recess on endoscopy compared to ESS alone for chronic adult frontal sinusitis.<sup>17</sup> In addition, Bolger et al performed a non-randomized prospective study of 107 patients that demonstrated 98% sinus ostia patency at 6 months after balloon sinus dilation.<sup>18</sup> Balloon sinus dilation has also been shown to be efficacious in advanced and complicated frontal sinus disease.<sup>19</sup>

Applicability to ARS and more specifically, pediatric ARS is topic of interest. In recent studies, balloon sinus dilation has been shown to be safe in children and has led to significant improvement in CRS symptoms.<sup>20</sup> Notably, the success rate of balloon sinus dilation plus adenoidectomy in these studies (80%) is comparable to the success rate of maxillary sinus irrigation plus adenoidectomy previously

reported in the literature.<sup>13,21</sup> Accessing the frontal sinus in an acutely infected field is of significantly greater difficulty than in the setting of chronic inflammation. To date, seven patients have been reported in the adult population with successful management of acute frontal sinusitis with balloon sinus dilation.<sup>22-25</sup> One case report has previously been published reporting the use of balloon sinus dilation in pediatric acute frontal sinusitis complicated by intracranial abscess.<sup>26</sup>

Although there are numerous surgical approaches to frontal sinus drainage, we advocate for the acceptable use of and consideration for balloon catheter dilation in the management of complicated acute frontal rhinosinusitis in the pediatric population. In our experience, balloon catheterization provided improved localization of the frontal sinus with ease of use and shortened anesthesia time in the challenging surgical milieu of an acutely infected field. Our review of the literature demonstrates safety and efficacy evidenced in prior analyses in the adult population, and we seek to contribute our case series as evidence of feasibility in the pediatric population.

We present the first case series of balloon sinus dilation in complicated pediatric acute frontal sinusitis. These four cases exemplify that balloon sinus dilation of the frontal sinus is a feasible treatment of acute frontal sinusitis in the pediatric patient. None of the patients in this series suffered intraoperative or postoperative complications. Furthermore, three of our four patients had severe disease resulting in extra-sinonasal complications. The fourth patient had acute frontal sinusitis on top of having an extensive history of CRS in combination with an underlying severe immunologic disorder. In all four approaches, the balloon sinus dilation catheter was able to be localized easily within the sinus and dilation allowed for the evacuation of the acutely infected contents.

## 4 | CONCLUSION

Prior reports have demonstrated the use of frontal balloon sinuplasty for use in CRS in the pediatric population. In this series, four pediatric patients suffered from complications of frontal ARS and a balloon hybrid technique was used successfully without complication and rapid resolution of symptoms. There are no recurrences to date at last follow-up, even in the presence of intracranial complications and underlying immunologic disorder. Balloon dilation of the frontal sinus is feasible in the treatment of complicated acute frontal sinusitis in the pediatric patient.

### CONFLICT OF INTEREST

The authors declare no conflicts of interest.

### ORCID

Tiffany P. Hwa  <https://orcid.org/0000-0002-7274-9366>

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