

Endoscopic approach to sinus disease

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Surgical modalities such as tonsillectomy and/or adenoidectomy, antral irrigations, and inferior meatal windows have not been effective in treating most cases of chronic sinusitis. Recent advances in technology have allowed a more direct approach to the obstruction and diseased tissue. The ethmoid sinus can now be approached directly and safely. The natural ostium to the maxillary sinus can be enlarged endoscopically with a high degree of patency. Techniques have been developed that limit the amount of scarring, and the procedure can be performed safely. The endoscopic ethmoidectomy and maxillary antrostomy has provided our best surgical modality for the treatment of chronic sinusitis in children to date. (J ALLERGY CLIN IMMUNOL 1992;90:496-505.)

Key words: Ethmoidectomy, antrostomy, computerized proposed tomography

MIDDLE MEATAL ANTROSTOMY

Another mechanism to ventilate and drain the antrum is through the middle meatus and the natural ostium. This had become a central theme in our current thinking about the cause of chronic sinusitis. As we have already noted, an early approach to irrigation of the sinus was through the natural ostium of the maxillary sinus. Oestrum was cited by Wilkerson¹ as the first in the United States to forcefully make a case for limited middle meatal windows. This approach was thought to be technically more difficult and dangerous than the inferior meatus antrostomy.² Proetz³ felt that natural ostium should not be violated because the nerves and primary vascular supply came through the natural ostium.⁴ He felt that the risk of protracted pain and paresthesia was high when the ostium was enlarged. Hilding⁵ performed a series of experiments that created maxillary antral windows at different sites in rabbits. Using three animals in each group, Hilding found that all three animals in which the natural ostium was widened became infected, and only two of three animals developed infection when the opening was made in the inferior portion of the sinus. He also created an ostium as high on the medial wall as possible and as far from the natural ostium as possible, and none of the three animals became infected. On the basis of this work, Hilding recommended that an antrostomy should be as far from the natural ostium as possible. It was on the basis of this study that the

Abbreviation used

CT: Computerized tomography

concept of middle meatal antrostomy fell into disrepute.¹ However, it should be noted in Hilding's defense that he stated, "It cannot be concluded from these experiments that exactly the same results would occur in the sinuses of other species or in man."⁵ Wilkerson¹ reported that the negative feelings against the middle meatal antrostomy were so strong that he stopped using the procedure despite good results. He later returned to this approach, and through his work,¹ interest was rekindled in surgery in the middle meatus.

Kennedy et al.⁶ retrospectively evaluated 117 antrostomies in 75 patients. Some surgical problems were encountered in 20 procedures. In three the ostium could not be identified, and in one bleeding from the ethmoid cavity was a complicating factor. Of the 95 procedures that had follow-up for more than 4 months, 98% were patent. Lavelle and Harrison⁷ reported a 94% patency rate in 150 patients undergoing intranasal middle meatal antrostomy over a 20-year period. Ninety-two percent of the patients in the series of Kennedy et al.⁶ had no symptoms or had significant improvement in their symptoms. The only complications reported were epiphora in two patients. Both occurred several months after surgery.

The middle meatal antrostomy carries a high patency rate. This approach allows removal of ostio-meatal complex disease or anatomic abnormalities at the natural ostium. It retains the orientation of the mucociliary transport, and physiologic drainage is re-established. This approach has significant theoretic

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1/0/38506

advantages and is the cornerstone in our current management of pediatric chronic sinusitis.

ETHMOIDECTOMY

External ethmoidectomy has been used to treat complicated sinus disease in children for several years. The external approach gives maximum visualization and safety because the periosteum is retracted away from the contents of the lamina papyracea ethmoid. Intranasal ethmoidectomy in the pediatric populations had not been recommended because of the small size of the ethmoid cavity and the increased potential for complications. The transantral approach to the ethmoid sinuses in children has not gained popularity because of the small sinus and fear of traumatizing the teeth. The endoscopic approach allows resection of disease in the ethmoid sinuses without scarring the face and has very little morbidity if the surgeon stays within the bounds of the ethmoid cavity.

The indications for endoscopic ethmoidectomy in children are being defined. The failure of tonsillectomy, adenoidectomy, antral lavage, and inferior meatal windows to control symptoms of chronic sinusitis has led to ethmoidectomy (partial or total) with middle meatal antrostomy as a surgical treatment. This procedure is safe in experienced hands.⁸⁻¹¹ Over the next several years, the technique will be modified and will evolve into a well-defined procedure with clear indications.

PREOPERATIVE ASSESSMENT

Unfortunately plain films both overread and underread the amount of disease located in the ethmoid sinuses and cannot be used as a screening device to select children for a full CT scan. The coronal CT scan has become a diagnostic cornerstone; however, one cannot decide to operate solely on the CT findings. It should be recalled that sinusitis waxes and wanes, and the CT scan cannot be used as the sole criterion for surgical intervention. Studies correlating the CT scan with the amount of disease seen at the time of surgical intervention have not been performed. It is currently not possible to make valid statements regarding the nature or the chronicity of the opacification seen on CT scans. A way to help differentiate between acute and chronic infections is to treat all patients with adequate medical therapy before the CT scan is performed. We currently use full-dose antibiotic therapy Amoxicillin-potassium clavulanate (Augmentin), 40 mg/kg/day, erythromycin, 40 mg/kg/day sulfisoxazole, 120 mg/kg/day (Pediazole), or cefuroxime, axetil (Ceftin), 30 mg/kg/day and topical nasal steroid sprays for 4 weeks before the CT scan is obtained. No good prospective studies define the efficacy of

long-term antibiotic therapy or the use of topical nasal steroid sprays. However, it has been our experience that the use of topical beclomethasone has cleared symptoms in a number of children. If disease is defined on the CT scan after appropriate therapy, one cannot assume the disease is irreversible and absolutely warrants surgical intervention. If opacification is present on CT scans but the patient has no symptoms, it would be prudent to observe the patient without surgical intervention.

The axial scan does not define the anatomy in a way that is useful to the surgeon and should be used primarily for defining disease in the sphenoid and frontal sinus. CT scans in the pediatric population are more difficult to perform because patients younger than 6 years usually require intravenous sedation. The newer spiral scanners offer a significant advantage in that they are so fast that sedation is no longer necessary. CT scans are expensive, although this is improving with time, and are not performed as frequently as plain sinus x-ray films. Once again the spiral CT scanners may offer a significant advantage.

As a matter of practicality, if the child's symptoms are severe enough and of sufficient duration that the surgeon and the parents would decide in favor of surgical intervention, then it is reasonable to proceed with a CT scan by sedating the child. If the child is old enough to obtain a CT scan without sedation, the indications may be more liberal.

Before the indications for ethmoidectomy are discussed, it is appropriate to discuss our current approach to the patient. I believe that surgical intervention is undertaken after maximum medical management has failed. Maximum medical management has not been well defined in prospective studies. If on initial evaluation there does not appear to be a good history or physical evidence of sinusitis, it is appropriate to reevaluate the child when ill to assess the signs and symptoms of disease. If the child has a history of signs and symptoms compatible with sinusitis but has not undergone an appropriate trial of medical management, it is appropriate to treat the patient with full-dose antibiotics and possibly topical nasal steroid sprays and antihistamines for 4 weeks and then reassess the patient. If the symptoms have been present for months or if symptoms have not resolved with medical management, it is appropriate to proceed with a coronal CT scan to define further the amount of disease present. If the symptoms have been present for a few months and the response to medical management has been good, then a trial of antibiotics with topical nasal steroids is appropriate. The clinician uses his or her judgment to decide the best course of action. Although no studies have eval-

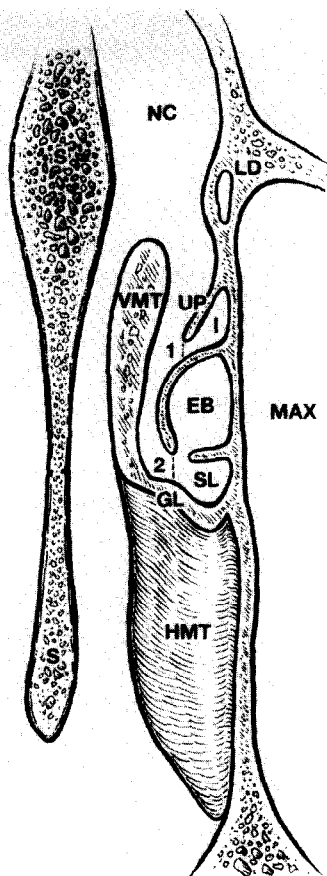


FIG. 1. Schematic drawing of the middle turbinate and the anterior ethmoid cells. *NC*, nasal cavity; *LD*, lacrimal duct; *VMT*, vertical middle turbinate; *UP*, uncinate process; *I*, infundibulum; *EB*, ethmoid bulla; *SL*, sinus lateralis; *GL*, ground (basal or grand) lamella; *HMT*, horizontal lamella; *S*, septum; *MAX*, maxillary sinus; *1*, inferior hiatus semilunaris; *2*, superior hiatus semilunaris.

uated the role of prophylactic antibiotics in sinusitis, I believe this modality will be important in the medical management of recurrent sinusitis.

ENDOSCOPIC APPROACH TO SINUS DISEASE

If the CT scan shows no evidence of sinus disease, surgical intervention should not be undertaken; the patient should be managed with topical nasal steroid sprays, and possibly antihistamines, and prophylactic A_b . If the CT scan shows "pansinusitis," surgical intervention will then likely be warranted; however, it is not absolutely necessary because we do not yet know the natural history of pediatric sinusitis and therefore cannot predict with certainty the outcome of prolonged medical management. The hardest judgments are those regarding surgical intervention in children who have minimal disease after prolonged medical management. As a general rule it is better to err

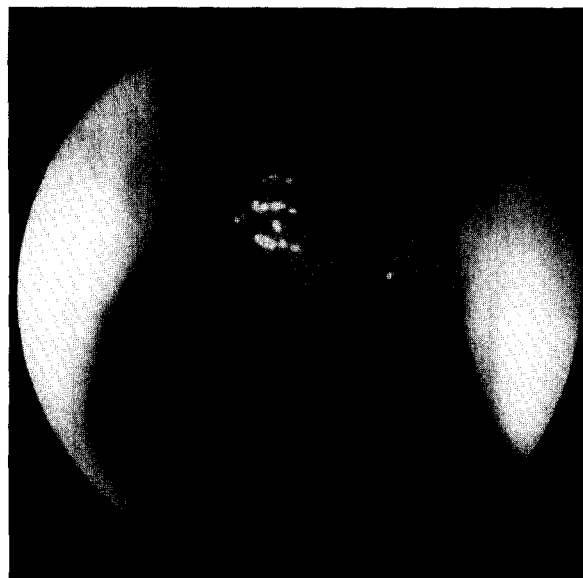


FIG. 2. Normal adenoid pad.

on the conservative side: that is, when in doubt, it is best to continue medical management and follow the child's symptoms. With time the best course will become clear. If the patient requires full-dose antibiotic therapy to remain free of disease, it is reasonable to proceed to surgery.

For all practical purposes, any manipulation of the nasal cavity in children has to be performed under general anesthesia. Surgery of the pediatric sinuses cannot be safely performed without a thorough knowledge of the anatomy of the nose. An extensive discussion of the lateral nasal anatomy will not be presented here because excellent articles and books are available on this subject.¹²⁻¹⁵ Fig. 1 is an axial diagram of the middle turbinate and the mid anterior ethmoid sinuses. This diagram will be used to help explain the surgical procedure. It is important to understand that all the anatomic structures noted in adults are present in children. The ethmoid cells, however, are much smaller than in adults, and the surgery must be precise, with careful identification of all landmarks.

As a basic principle, sinus surgery in children should be as conservative as possible and yet extensive enough to correct the problem. Disease in the pediatric age group is located primarily in the anterior ethmoid and maxillary sinuses.¹⁶ Stammberger¹⁷⁻¹⁹ has noted that the anterior ethmoid, especially the infundibulum, holds the key to recurrent sinusitis. In some children surgery may require only opening the infundibulum (although in our experience this is rare), whereas others will require anterior and posterior ethmoidectomy and maxillary antrostomy. Rice and Schaefer²⁰ have noted, the endoscopic techniques developed in Europe by Messerklinger and Wigand were for disease

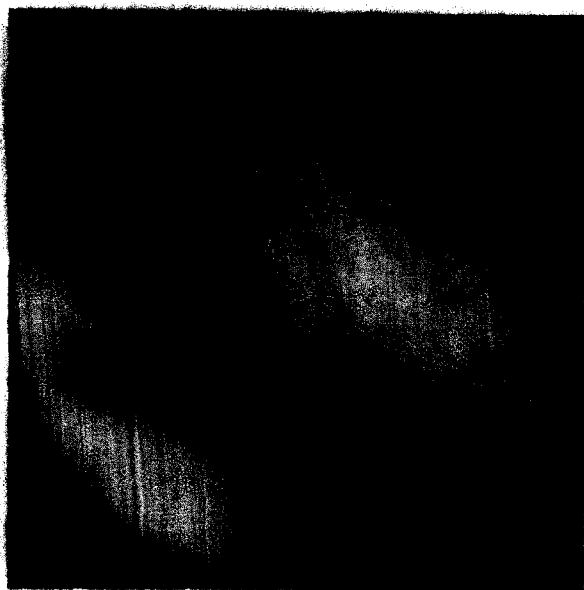


FIG. 3. Purulence from the maxillary sinus.



FIG. 4. Purulence from the superior meatus and sphenoid recess.

at two ends of the spectrum—Messerklinger^{14, 21} for early anterior ethmoid disease and the Wigand¹³ technique for pansinusitis or in patients in whom the more conservative procedure is apt to fail. Most children have disease located in the anterior ethmoid and maxillary sinuses; therefore I have adopted the Messerklinger technique. Stammberger^{18, 19, 22, 23} and Kennedy^{6, 24, 26} have further clarified and popularized this approach. The advantages of this approach in children are that it only removes the diseased tissue and leaves the middle turbinate and as much normal mucosa as possible. The nose is narrow in children, and the procedure, regardless of the technique, can be very challenging. Radical sphenoidectomies can be performed with both techniques; however, it is not frequently necessary in children.

Regardless of the technique, intranasal endoscopic surgery has two goals: (1) to create wider communication between the nasal cavity and the paranasal sinuses and (2) maximum preservation of normal anatomy and mucosa. This does not require removal of all of the cells and mucosa but does require opening the areas of obstruction. As Wigand states,¹³ intranasal endoscopic operations on the paranasal sinuses for chronic sinusitis are mainly limited to opening the narrow bony points to restore ventilation and internal drainage. Therefore the operation should be tailored to the individual patient and the extent of the chronic sinusitis.

I have tried to standardize the approach as much as possible in an effort to minimize the risk of complications and yet perform an adequate operation. The patient will undergo a general anesthetic and the nose

vasoconstricted. After 5 minutes the nose is injected with 1.5 to 2 ml of 1% lidocaine with 1/100,000 epinephrine to further vasoconstrict the nose. After the nose has been adequately vasoconstricted, it is examined with a 0- or 30-degree 2.7 mm telescope. The first pass is along the floor of the nose, and the size of the adenoid pad is examined (Fig. 2). Any purulence in the nose is carefully suctioned, and its apparent source is a valuable indicator of the sinus involved. If the secretions are thick, tenacious, and from the middle meatus, it is likely to be coming from the maxillary sinus (Fig. 3). If it is coming from the medial side of the middle turbinate, its source is the superior meatus (posterior ethmoid cells) or the sphenoid sinus (Fig. 4). Purulence from the root of the middle meatus is likely originating from the frontal sinus or agar nasi cells (Fig. 5). Examination of the sphenoid recess in children is difficult even with a 2.7 mm telescope because of the very narrow channel.

Identification of the uncinate process is perhaps the most crucial step in the operation. The uncinate process can be identified in all cases except those of the hypoplastic maxillary sinus. The hypoplastic sinus can be clearly identified on coronal CT scans. The uncinate process is smaller and thinner than in adults, therefore the incision should be made carefully to prevent incising the ethmoid bulla or lamina papyracea. The uncinate process is removed and the ethmoid bulla is exposed (Fig. 6). On occasion a concha bullosa will be present and cause enough obstruction that the procedure cannot be performed without removal of the concha bullosa (Fig. 7, A and B).

The ostium of the maxillary sinus is identified with

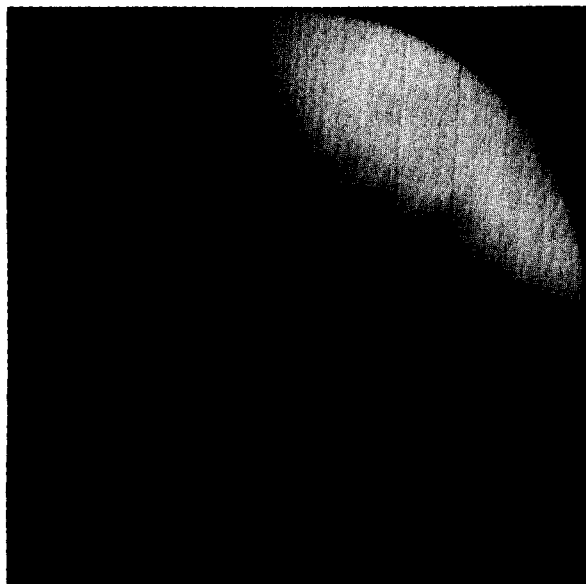


FIG. 5. Purulence from the superior middle meatus and the frontal recess.

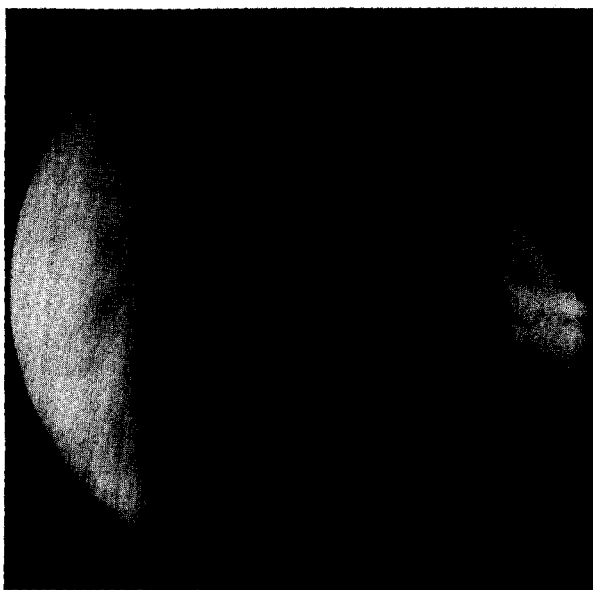


FIG. 6. The uncinate process is removed to expose the ethmoid bulla.



FIG. 7. A, View of conchae bullosa with a 0-degree telescope. **B,** Lateral half of the middle turbinate removed.

a 30-degree telescope. If the ostium is obvious and not obstructed, it should not be enlarged. If not clearly seen, the ostium is enlarged. It is important to make sure that the enlarged opening into the maxillary sinus is connected to the natural ostium. If not, there will be an accumulation of secretions, which will result in persistent symptoms (Fig. 8, *A* and *B*).

The ethmoid bulla can be entered with minimal trauma and risk, with a J-curette placed in the lower quadrant (Fig. 9). An upbiting cut is then inserted

into the bulla, and a portion of the anterior face is removed (Fig. 10). The bulla is examined, and if the mucosa is normal, the procedure may be stopped at this point. If there is diseased mucosa or purulence in the bulla, an anterior ethmoidectomy should be performed. The medial wall of the bulla will guide the surgeon to the basal lamella. This lamella is the anterior wall of the posterior ethmoid cells.

If an anterior ethmoidectomy is performed, the entire ethmoid bulla should be removed, and the lamina

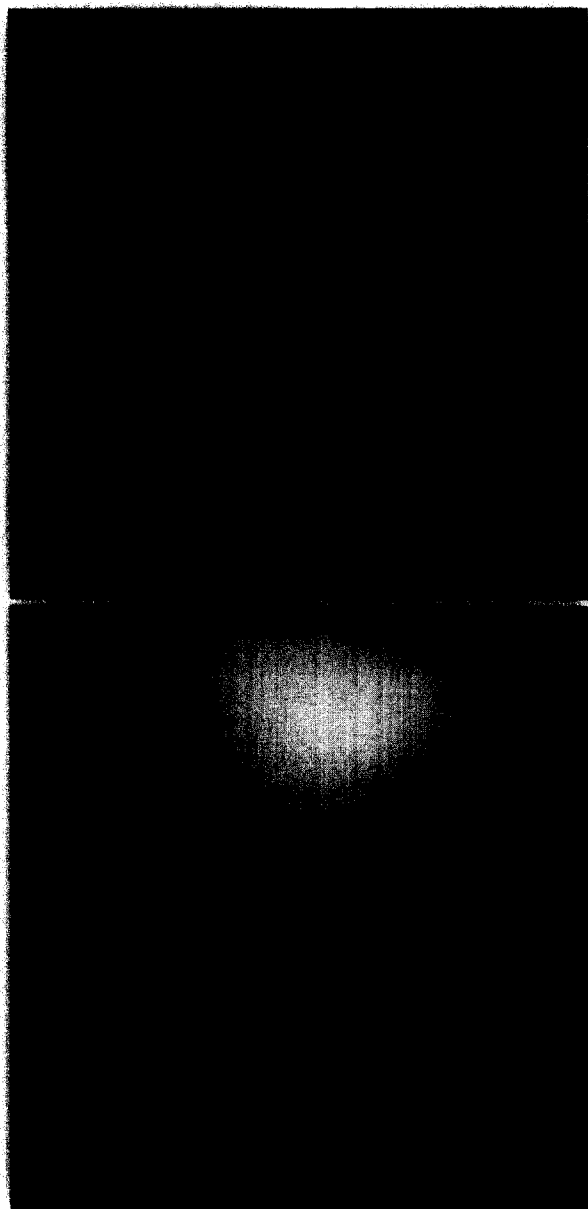


FIG. 8. A, Patient with persistent symptomatic secretions resembling moist mucosa can be seen on the lateral nasal wall just anterior to the enlarged ostium. **B,** When secretions are removed, the natural ostium can be identified and noted not to be connected to the enlarged ostium. Connecting the two resulted in resolution of symptoms.

papyracea must be clearly identified by its smooth texture and yellow color (Fig. 11). This is a boundary that can be followed into the posterior ethmoid.

Identification of the third basal lamella is important because it marks the anterior border of the posterior ethmoid cells. This lamina is best characterized as an ill-defined bony connection between the lamina papyracea and the middle turbinate. The posterior cells are larger and the roof of the ethmoid is easier to identify posteriorly. Only diseased mucosa should be

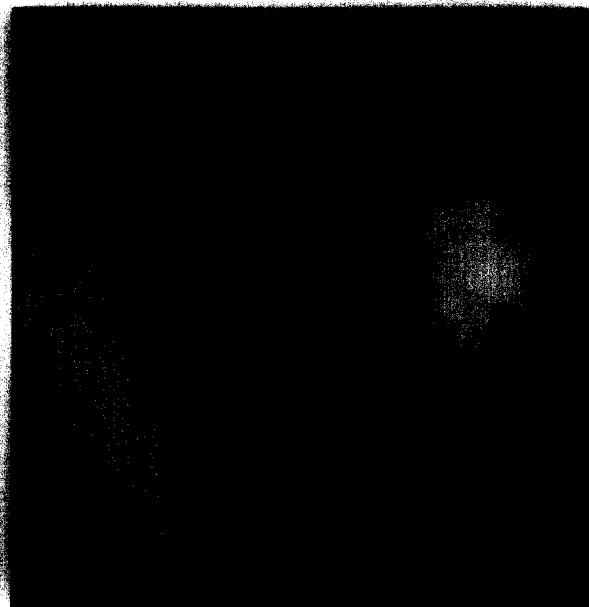


FIG. 9. J-curette enters the ethmoid bulla along the anterior, inferior, and medial margin.

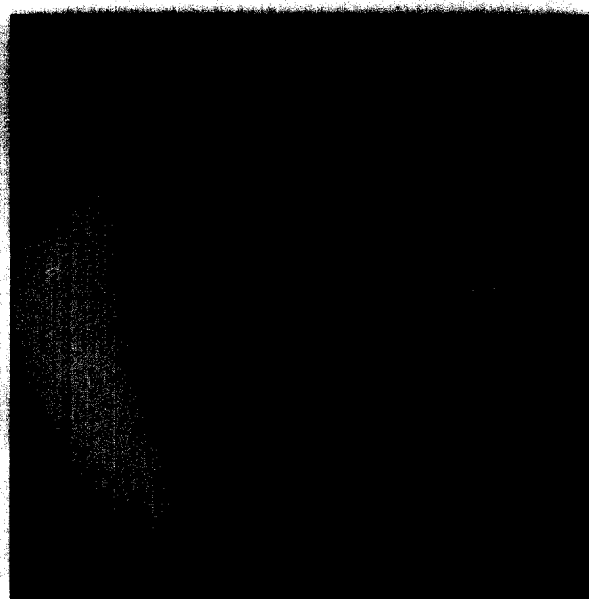


FIG. 10. A 45-degree upbiting cup removes the anterior wall of the ethmoid bulla.

removed from the roof of the ethmoid. If these cells are free of disease, the posterior cells can be left intact. The most posterior ethmoid cell, the Onodi cell, shows varying degrees of development in children (Fig. 12). It is my impression that the optic nerve is somewhat more protected in children; however many teenagers show extensive development of the sinuses, and I have seen the optic nerve exposed in the posterior ethmoid



FIG. 11. The ostium of the maxillary sinus will help locate the floor of the orbit and the lamina papyracea (pediatric cadaver dissection).



FIG. 12. The posterior-most ethmoid cell (Onodi cell) is the largest and clearly identifies the posterior roof of the ethmoid and lamina papyracea.

of a 7-year-old child. Care is used along the lateral and superior walls of the sphenoid and posterior ethmoid sinus to prevent damage to the optic nerve.

The sphenoid is not as frequently diseased in children and therefore is not frequently opened. It is usually opened through the ethmoid because the sphenoid recess in children is so narrow and difficult to visualize.

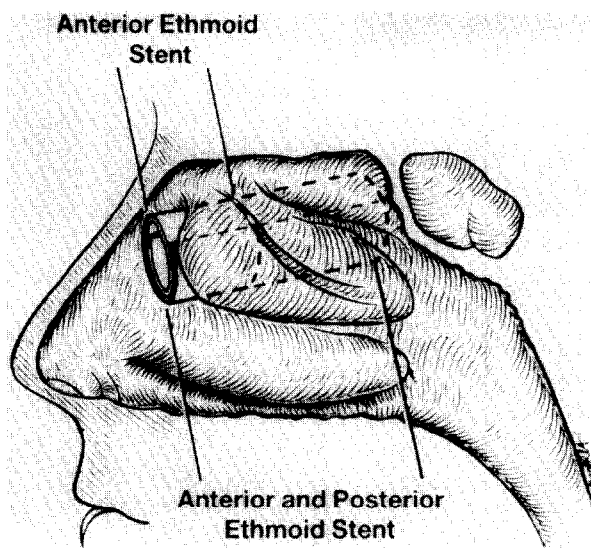


FIG. 13. Diagram of the length and position of Gel film for an anterior and anteroposterior ethmoidectomy.

Once the roof of the ethmoid has been identified in the posterior cells, the roof can be followed into the anterior ethmoid cells. If the mucosa along the roof is normal, every effort should be made to leave it intact. The appropriate management of the developing frontal recess and frontal sinus is not clear. It would seem prudent to be very conservative in the frontal recess until more is known about development after surgery. When the recess is opened, every effort is made to leave the normal mucosa intact.

The postoperative care for the pediatric patient undergoing sinus endoscopy is modified because of poor patient compliance. Even anterior rhinoscopy cannot be performed after surgery in some patients. Any postoperative cleaning must be performed under general anesthesia. At the time of surgery, Gel film (UpJohn, Kalamazoo, Mich.) is rolled and placed in the middle meatus (Fig. 13). If the stents are appropriately placed in the middle meatus, the children will be able to breathe through the nose with minimal problems. Experience has shown that the Gel film should be removed approximately 2 weeks after surgery. A variable amount of granulation tissue accumulates in the area of the frontal recess and the maxillary antrostomy. The granulation tissue in these areas should be gently removed. A half to a full roll of Gel film is placed back in the cavity and allowed to absorb. The patient is kept on full-dose antibiotics until the stent falls out or has absorbed (usually within 2 to 3 weeks). Prophylactic antibiotics are used until the cavity is free of crusting. Scarring with this method has been well controlled (Fig. 14). We have had problems with scar-



FIG. 14. Postoperative view of an ethmoid cavity without scarring.

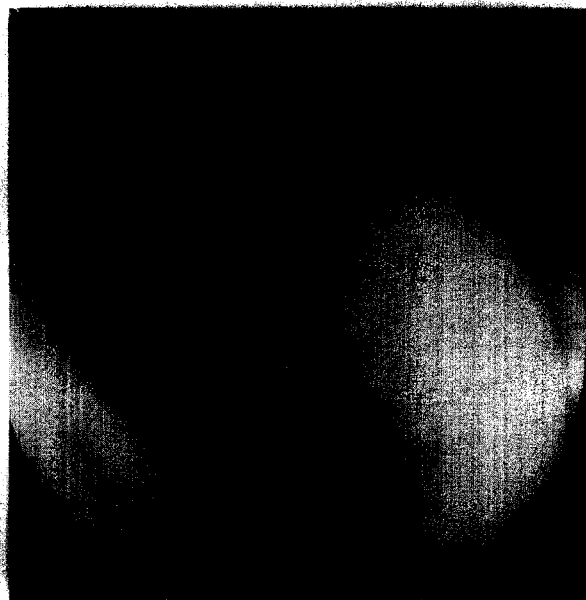


FIG. 15. Postoperative view of an ethmoid cavity with scarring when Gel film was not used.



FIG. 16. **A,** Coronal CT scans of child with chronic sinusitis of the ethmoid and maxillary sinus. **B,** Sagittal reconstruction through the ethmoid sinus. **C,** Postoperative view of the same child after and ethmoidectomy and maxillary antrostomy. **D,** Sagittal postoperative reconstruction through the ethmoid sinus.

ring (Fig. 15) when we have deviated from this routine. The success of the surgical intervention is best assessed by resolution of the patient's symptoms. A follow-up CT scan, particularly if sedation is required, seems unwarranted if the patient has no symptoms. If the patient has symptoms and must continue antibiotic therapy to remain clear, then a repeat CT scan would seem warranted. Fig. 16, A and B, is the preoperative CT scan of a 4-year-old patient who had persistent symptoms of chronic sinusitis. He underwent endoscopic sinus surgery and had intermittent symptoms and thus a repeat CT scan was performed; the results are shown in Fig. 16, C and D. Good resolution of maxillary and ethmoid sinus disease can be seen.

Gross et al.⁸ and Lusk et al.²⁷ have found that endoscopic ethmoidectomy can be performed safely in children, and the initial follow-up of pilot studies has been encouraging. Gross et al.⁸ whose follow-up ranged from 3 to 13 months, initially reported encouraging results. Lusk and Muntz¹¹ reported on 31 patients with chronic sinusitis who underwent endoscopic ethmoidectomy. Twenty-six percent of the patients had asthma, and 23% had varied types of immunodeficiencies. Each of the children had failed prolonged medical management, and many had multiple surgical procedures, including inferior nasal antral windows in 48% of the children. The mean duration of symptoms in these children was 26 months. At the end of 1 year, 71% percent of the parents gave their child a normal rating. If the children with systemic disease, such as cystic fibrosis and immunodeficiencies, were excluded, 81% of the parents gave their children a normal rating. Twenty-three percent were improved but not normal according to their parents and 6% were unchanged. None of the patient's symptoms were worse after surgery, and no complications occurred. Although difficult, endoscopic sinus surgery can be safely performed in children. The indications, however, have not been appropriately defined and will undergo continued revision with prospective studies.

Orbital complications can occur in the form of (1) blindness resulting from direct injury to the optic nerve or resulting from retrobulbar hemorrhage, (2) diplopia resulting from trauma to the orbital muscles or secondary fibrosis, and (3) epiphora resulting from trauma to the lacrimal duct. The best prevention of these complications is a thorough knowledge of the anatomy in general and specifically of any congenital anomalies in the patient.

The other major complication that can occur is a cerebrospinal fluid leak. Fortunately, this is relatively rare.^{28, 29} The cause is usually penetration of the fovea ethmoidalis. A thorough knowledge of the anatomy is crucial to prevent this complication.

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Current concepts in the surgical management of chronic and recurrent acute sinusitis

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It was previously believed that sinusitis lasting longer than 3 months might lead to irreversible disease. Experience with functional endoscopic sinus surgery indicates that this is rarely the case. Functional endoscopic sinus surgery describes an approach whereby target areas of obstruction are cleared of disease, which allows for ventilation of secondarily involved sinuses and return of mucociliary function. Although endoscopic sinus surgery is one of the techniques most frequently used to manage chronic sinus disease, it is not a suitable surgical approach for every otolaryngologist or all patient settings. Success with this endoscopic approach for chronic sinus disease is based primarily on rigorous perioperative medical care and postoperative surgical debridement. The greatest advancement that the nasal endoscope has brought to patient care is the ability to diagnose disease and follow objectively the effects of different treatment modalities. This advantage is recognized by allergists and used at several centers. (J ALLERGY CLIN IMMUNOL 1992;90:505-11.)

Key words: Surgery, sinusitis, endoscopy, therapy, diagnosis

In the late nineteenth century, Dr. Caldwell from New York and Dr. Luc from Paris independently described the radical transbuccal maxillorhinostomy for the treatment of chronic maxillary sinus disease. Even at that time, however, it was recognized that the ethmoid sinuses were at the root of the problem for recurrent maxillary sinusitis. In the 1940s, published results from an experiment performed on only a few

Abbreviation used

CT: Computed tomographic(y)

rabbits suggested that surgical disruption of the natural ostium of the maxillary sinus was doomed to failure.¹ This report suggested that surgical opening in a gravity-dependent position far away from the natural ostium was more desirable for ventilation of the maxillary sinus. This limited research promoted the concept of inferior antrostomies and Caldwell-Luc procedures for the management of chronic sinus diseases despite the fact that nearly 50 years earlier the anterior ethmoidal sinuses were recognized as the seat of recurrent maxillary sinus disease. It is now known that complete stripping of the maxillary sinus in rab-

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