Paparella III: Section 2: Disorders of the Head and Neck

Part 1: Nose and Paranasal Sinuses

Chapter 5: Endoscopic Sinus Surgery

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The theoretic principles of functional endoscopic sinus surgery, and the detailed diagnostic and anatomic information about the ostiomeatal complex may be beneficially applied to the general management of patients with sinusitis. Thus, these principles have application both in the medical management of patients and in nonendoscopic surgical techniques. Indeed, the use of endoscopes during function surgery is subordinate to an understanding of the principles involved and constitutes a relatively minor aspect of the overall concept of functional endoscopic surgery (FES).

The concepts of FES differ considerably from those of the more traditional exenterative techniques. With the latter, the eradication of maxillary sinus disease was often held to be the crux of successful therapy aimed at the other sinuses. To this end, the importance of complete surgical removal of all diseased mucosa was often emphasized. Functional techniques, in contrast, stress the crucial role of sinus obstruction in the pathogenesis of sinusitis. The restoration of ventilation and the reestablishment of mucociliary clearance are considered key to the resolution of disease and maintenance of healthy sinus mucosa. The surgery is therefore aimed at the removal of obstruction within the ostiomeatal complex. Although in some instances, pathologic conditions within the maxillary and frontal sinuses are irreversible or represent the primary cause of persisting disease, with careful diagnostic evaluation this appears to occur less frequently than previously identified (Kennedy et al, 1985; Stammberger, 1986a; Messerklinger, 1987).

The diagnosis of disease within the narrow mucosa-lined channels and complicated anatomy of the ostiomeatal complex necessitates meticulous diagnostic evaluation. Although secondary disease within the frontal and maxillary sinuses is demonstrated by routine plain film radiographic studies, by ultrasound, and in many cases even by transillumination, underlying problems in the ostiomeatal complex are poorly seen on standard radiographs and are not visualized at all with A-mode ultrasound. In order to accurately define this area, a combination of endoscopy and radiographic tomographic techniques is essential (Zinreich et al, 1987). Basic prerequisites include knowledge regarding mucociliary clearance and a detailed understanding of the regional anatomy.

Mucociliary Clearance

Early studies of mucociliary clearance were performed by Proetz (1941) and Hilding (1950). Hilding meticulously examined normal mucociliary patterns and the effects of different operative procedures. However, it was left to Messerklinger to provide detailed documentation, both of normal patterns and pathologic changes. The mucociliary blanket consists of a sol (periciliary fluid) layer and a gel layer. The ciliar beat rhythmically within the former, advancing the gel layer in predetermined patterns. The blanket provides a surface for particulate matter impaction, aiding the nose in cleansing, as well as humidifying and warming the air stream. The impacted particles are then passed posteriorly into the nasopharynx and are harmlessly swallowed (Proctor, 1982).

In the frontal sinus, the mucociliary flow pattern passes superiorly along the intersinus septum, laterally along the roof, and inferomedially down the lateral wall. The mucus enters the frontal recess after exiting through the internal opening of the sinus. Recirculation occurs within the frontal recess, with significant mucociliary flow back into the sinus (Messerklinger, 1967). Some of the mucus, however, passes through the ostiomeatal pathways into either the middle meatus or the superior aspect of the hiatus semilunaris, depending on the individual anatomic variant present.

Within the maxillary sinus, mucociliary clearance spreads out in a starlike pattern from the floor, ascends along each wall, and passes towards the natural ostium. From here, the drainage passes into the narrow ethmoidal infundibulum, joining with the secretions from this area. In some cases, the secretions then join with those from the frontal recess and the frontal sinus before passing out through the inferior portion of the hiatus semilunaris into the middle meatus (Hilding, 1944). The anterior ethmoidal, frontal, and maxillary sinuses are therefore closely related and rarely inflamed in isolation, although the degree of secondary involvement may vary.

The posterior ethmoidal sinuses and the sphenoidal sinus drain into the sphenoethmoid recess. In terms of mucociliary drainage, therefore, the posterior ethmoidal cells should be considered different sinuses from the anterior cells. However, anatomically they are separated only by a thin bony partition, which may be involved by disease.

Although mucociliary clearance may temporarily cease in the presence of infection, this is not uniformly the case. Friedrich (1984) demonstrated that when mucociliary clearance is re-established, even in the presence of an inferior meatal antrostomy, clearance is always toward the natural ostium. The concept of dependent drainage of a sinus is therefore incompatible with current knowledge of mucociliary clearance.

Surgical and Radiologic Anatomy of the Ostiomeatal Complex

The ethmoid sinus is divided into anterior and posterior cell groups by the basal or ground lamella of the middle turbinate. This obliquely curving bony septum connects the middle turbinate to the lateral nasal wall and constitutes the posterosuperior boundary of the middle meatus. Cells anterior to the ground lamella are generally smaller and open into the middle meatus, whereas the larger cells open posteriorly through the superior or supreme meatus into the sphenoethmoidal recess. The number and size of the ethmoidal cells are widely variable and different in every patient.

The roof of the ethmoid sinus is formed by the floor of the anterior cranial fossa and may be horizontal or sharply downsloping medially. The latter creates a large difference between the height of the cribriform plate medially and the ethmoidal roof laterally (Keros, 1962). The roof is also thin medially and may have a significant area of dehiscence adjacent to the ethmoidal vessels.

The anterior ethmoidal cell group consists of the cells of the bulla ethmoidale and the cells superior to it, cells that open into the frontal recess, and the ethmoidal infundibulum. An additional anterior ethmoidal cell, the sinus lateralis, may extend posteriorly for a variable distance invaginating the basal lamella. Extreme anterior ethmoidal pneumatization occurs in approximately 10 to 15 per cent of the population. These agger nasi cells lie anterior to the opening of the frontal sinus in close relationship to both the frontal sinus and the lacrimal sac. The middle turbinate is also pneumatized in approximately 15 per cent of the population and constitutes a cell of the anterior ethmoidal group, opening either into the frontal recess or, less commonly, into the sinus lateralis.

The uncinate process is a bone that fuses with the lateral nasal wall anteriorly, inferiorly, and sometimes superiorly. It forms the medial wall of a narrow air space, the ethmoidal infundibulum. Posteriorly, the ethmoidal infundibulum communicates freely with the hiatus semilunaris - the posterior free border of the uncinate process delineating the anterior limit of hiatus, whereas the anterior wall of the bulla delineates it posteriorly. Typically, the ethmoidal infundibulum ends blindly superiorly, the uncinate process fusing with the lateral nasal wall. In some instances, however, it communicates with the frontal recess or with the agger nasi cells.

The maxillary sinus typically opens into the inferior aspect of the ethmoidal infundibulum through an ostium that lies recessed in the superomedial aspect of the sinus. Effectively, therefore, the maxillary sinus typically drains through a canal that is formed in part by a portion of the anterior ethmoid bone and may be up to 22 m in length (Wilkerson, 1949). In approximately 15 per cent of patients, accessory maxillary ostia are present, opening directly into the middle meatus. However, these ostia typically do not receive active mucociliary clearance from the sinus. The incidence of accessory ostia appears to be higher in patients who have infundibular obstruction or a history of maxillary sinus disease, suggesting that they may occur as a result of a pathologic condition and then remain patent. Rarely, the natural ostium itself may open directly into the middle meatus, posterior to the free border of the uncinate process.

The frontal sinus tapers inferiorly toward the internal os. The internal os lies in intimate relationship to the frontal recess cell inferiorly and, when present, the agger nasi cells anteriorly. Most frequently, the drainage of the frontal sinus passes medial to the uncinate process to open into the middle meatus. Less frequently, however, it may pass into the ethmoidal infundibulum or into the superior aspect of the hiatus semilunaris. Thus, the frontal sinus is easily affected by frontal recess disease in all cases, and to a variable degree by narrowing of the anterior middle meatus, or disease within the ethmoidal infundibulum, depending on the anatomic variation present.

The posterior ethmoidal cells drain through several openings into the superior or supreme meatus or into the sphenoethmoidal recess. The sphenoidal sinus opens into the sphenoethmoidal recess close to the midline. Surgically, it is important to recognize that 1 cm lateral to the midline the most posterior ethmoidal cell typically pneumatizes in a superolateral direction toward the anterior clinoid process. The sphenoidal sinus therefore lies inferomedial to this cell and not posterior to its posterior limit. Laterally, the posterior ethmoidal cell may pneumatize to a variable extent around the optic nerve, or occasionally the nerve may be dehiscent into the sinus. The optic nerve has a more superior relationship with regard to the sphenoidal sinus, but again may significantly indent the superolateral aspect of the sinus. The carotid artery relates to the lateral wall of the sphenoidal sinus more inferiorly, at which point it may produce a significant bulge or have a bony dehiscence.

Anatomic evaluation, therefore, demonstrates the close interrelationships between the sinuses. In particular, the dependence of the frontal and maxillary sinuses on the anterior ethmoid bone and middle meatus for ventilation and drainage is clearly demonstrated. Although both the frontal and the maxillary sinuses could be considered as having drainage ducts, both of these "ducts" can typically be widely opened by removal of the adjacent ethmoidal structures.

Anatomic Variations

Although the sinuses are subject to wide normal variation, certain anatomic variations may compromise normal sinus ventilation and drainage, thus becoming a significant causative factor in the pathogenesis of sinus inflammation. A relationship between severe septal deformity and sinusitis has been previously recognized. However, there is a significantly more immediate relationship between anatomic variations in the ostiomeatal complex and sinus infection. These variations have not been recognized as frequently in the past, as they are identified only by careful diagnostic examination using endoscopy and in some cases computed tomography (CT) (Messerklinger, 1978, 1987; Kennedy et al, 1985; Stammberger, 1986a).

The middle meatus may be narrowed by massive enlargement of an air cell within the middle turbinate (concha bullosa) or by a middle turbinate with a marked large convexity (paradoxic middle turbinate). Similarly, the hiatus semilunaris may be narrowed or closed by enlargement of the bulla ethmoidale. The maxillary sinus ostium may be narrowed by a large air cell in the roof of the sinus (Haller cell), and the frontal sinus ostium may be narrowed by large agger nasi cells. Other variations such as medial or lateral rotation of the uncinate process can also give rise to significant narrowing in one or another area of the ostiomeatal complex.

Pathogenesis of Sinusitis

The crucial role of ventilatory obstruction in the pathogenesis of sinusitis has been demonstrated (Carenfelt, 1979). Studies have demonstrated the PO_2 to be consistently lowered within the maxillary sinus during infection. Additionally, pressure recording from within the sinus is dampened or lost and the PO_2 typically remains low in patients with recurrent sinusitis (Aust and Drettner, 1974; Drettner, 1965). CT and endoscopic studies both demonstrate that inflammation may persist within the ostiomeatal complex between attacks of maxillary and frontal sinusitis.

The relationship between sinusitis and impaired mucociliary function remains less well elucidated. Primary ciliary dyskinesia can clearly lead to sinusitis, but the relationship of less severe or acquired ciliary problems to the development of sinusitis is less easily defined. In terms of localized mucociliary obstruction, endoscopic evaluation of patients strongly suggests a significant causative role, even when alternative ventilation routes are present.

In evaluating patients with recurrent sinusitis, consideration must also be given to the patients' immunologic status. Although studies evaluating the role of allergy in sinusitis have been less than conclusive, basic precepts and clinical experience certainly suggest a significant relationship. Similarly, the possibility of IgA or selective IgG deficiency, combined immune deficiency, or acquired immune deficiency must be considered in patients with recurrent or persistent infection.

The concepts of FES have developed out of improved understanding of sinus pathophysiology. However, many factors associated with the pathogenesis of inflammatory sinus disease remain poorly understood. The role of minor mucociliary clearance impairment occurring in the presence of patent ostiomeatal pathways needs to be defined. Little is known with regard to the incidence and effect of bony osteitis in the persistence of chronic mucosal changes, although clinical observation again suggests this may be a significant factor. Similarly, the diagnosis of what constitutes irreversible mucosal disease and the factors associated with irreversibility require better definition.

Diagnosis

The keystone of functional endoscopic sinus surgery is the ability to accurately evaluate the ostiomeatal complex by comprehensive nasal endoscopy and, when indicated, CT. In addition to diagnosing active infection, the aim is to identify focal areas of obstruction created by minor areas of persistent localized inflammation, anatomic deformity, or scarring (Kennedy et al, 1987a). When possible, the sinus ostia are identified. Although the sphenoidal sinus ostium is frequently visible, the maxillary sinus ostium and the ethmoidal infundibulum are typically hidden from view by the uncinate process. Disease within the ethmoidal infundibulum is frequently identified by mucosal prolapse into the hiatus semilunaris or by the presence of inflammation on the medial aspect of the thin uncinate process. Similarly, the presence of maxillary sinus disease may be demonstrated by changes on the medial aspect of the membranous portions of the sinus wall (fontanelles). Even though the deeper structures of the ostiomeatal complex cannot be identified and the extent of disease cannot be ascertained by endoscopy, it offers a more precise view of the structures of the middle meatus than can be obtained by CT.

Comprehensive nasal endoscopy is not intended primarily as a prelude to surgical intervention but as an accurate means of direct evaluation of nasal and sinus disease. It enables visualization of problems requiring medial therapy and, when necessary, accurate culture and biopsy. Similarly, the response to antibiotics, steroids, allergic management, or other medical therapy can be assessed, and the therapy can be changed or dosage levels can be titrated long before changes are observed by anterior rhinoscopy. Following surgery, a more accurate assessment of surgical results may be achieved, and in cases of recurrent or persistent disease, early intervention is possible.

Rigid Hopkins telescopes are preferred for nasal endoscopy because of their superior optical resolution and the advantages of deflected angles of view rather than the necessity to deflect the tip of a flexible instrument within the narrow nasal passages. The introduction of instrumentation alongside the telescope is also easier with a rigid endoscope. For diagnostic nasal endoscopy, the 4-mm 30-degree and 2.7 mm 30- and 70-degree telescopes appear to be the most useful.

Systematic nasal endoscopy may be performed in either the sitting or the supine position and is performed as an additional part of the routine examination of patients with chronic sinusitis. After the application of decongestants and topical anesthetic, the 4-mm 30-degree telescope is usually selected first to provide an overall view of the nose and nasopharynx. The telescope is initially passed along the floor of the nose. This allows the overall nasal anatomy, the presence of pathologic secretion, and the condition of the nasal mucosa to be evaluated. In some cases, it may also be possible to examine the inferior meatus and to identify the nasolacrimal duct. The presence of a patent antrostomy allows easy visualization of the antral mucosa, although a telescope with greater deflection (70-degree)) is required for identification of the sinus mucosa around the ostium.

A second pass of the telescope below the middle turbinate allows examination of the anterior and inferior aspects of the middle meatus and of the sphenoethmoidal recess. As the second pass is begun, the infundibular wall can be viewed. More posteriorly, the fontanelles and inferior aspect of the hiatus semilunaris are seen. The telescope is then passed medial to the middle turbinate into the sphenoethmoidal recess. Here the sphenoidal sinus ostium and the openings of the posterior ethmoidal cells are viewed.

As the telescope is again brought anteriorly, it can be inserted into the posterior aspect of the middle meatus to inspect the bulla ethmoidale, hiatus semilunaris, infundibular opening, and occasionally the maxillary sinus ostium. When the middle meatus will not admit the 4-mm endoscope, the Hopkins 2.7-mm 30- or 70-degree telescope is used. Occasionally, gentle medial subluxation of the middle turbinate, or the use of a cannula placed under the middle turbinate, is helpful in allowing the use of a 4-mm instrument.

Maxillary sinus endoscopy is not a routine part of nasal endoscopy and is usually performed when some unusual radiographic pathologic feature is present or if a therapeutic endoscopic maxillary sinus procedure is planned. In adults a 5-mm trocar and cannula is typically used with a 30- or 70-degree 4-mm telescope. In children, a smaller trocar and cannula and a 2.7-mm telescope is substituted. The sublabial route is the preferred method of access, except in children or in cases of suspected malignancy. The canine fossa provides for the greatest arc of rotation of the cannula and the best visualization of the maxillary ostial area. After infiltrating local anesthetic, the cannula is inserted through the upper lateral aspect of the canine fossa. The sinus is then inspected with the 30- or 70-degree telescope. Cysts and small polyps may be removed through this route, and lesions may be biopsied. However, more difficult disease requires access through a widened middle meatal antrostomy for removal. No sutures are required following the procedure, but the patient should be instructed to avoid blowing the nose for several days to avoid subcutaneous emphysema.

The presence of significant endoscopic findings that do not resolve after medical therapy, or a well-documented history of chronic or recurrent sinusitis, provides the basis for proceeding with CT, which is used to reveal mucosal changes deeper in the ostiomeatal complex that are not visible endoscopically, to identify the extent of disease, and to detail the anatomy in cases in which surgery is indicated. The CT examination should be performed after acute exacerbations of recurrent sinusitis have been optimally treated medically. The intent of the examination is to demonstrate the underlying cause of recurrent or persistent inflammation and not the secondary mucosal changes. Performing the study after resolution of the secondary changes allows more detailed evaluation of the inflammatory changes or anatomic variations that perpetuate chronic or recurrent acute sinusitis.

The coronal plane provides optimal CT visualization of the anterior ethmoidal sinus and ostiomeatal structures. However, this requires the patient to assume a prone position with the head hyperextended on the scanner bed, a position that is not always possible in the elderly patient. Conversely, the presence of metallic dental artifacts does not usually interfere with good definition of the ostiomeatal complex and typically therefore is not a contraindication to scanning in this plane. Scanning extends from the frontal sinus anteriorly to the sphenoidal sinus posteriorly and is usually performed without intravenous contrast enhancement. To assure optimal soft tissue demonstration, it is important that the CT images of the sinuses be adequately magnified and photographed with appropriate windowing. Window width and center should be similar to those used for the evaluation of lung parenchyma. In cases in which direct coronal scanning is precluded, axial scans are taken, and indirect coronal reconstructions are generated from them. Special emphasis is placed on the anterior ethmoidal region (Zinreich, 1987).

Surgery

Sinus inflammation that persists despite appropriate and adequate medical therapy, and documented recurrent acute sinusitis with identifiable and related abnormalities in the ostiomeatal complex, are considered potential indications for surgical intervention. However, the mere presence of areas of sinus opacification on CT is not an indication for surgical intervention, as asymptomatic mucosal disease may be demonstrated on CT. Changes identified by CT must therefore be correlated with symptomatology and endoscopic findings.

There is significant variation in endoscopic surgical technique. The two most important variants are FES and sphenoethmoidectomy under endoscopic control (Kennedy, 1985; Stammberger, 1986b; Wigand et al, 1978). With FES, each operation is tailored to the disease that is present. Thus, the operation is discontinued when areas of disease that disrupt ventilation or mucociliary clearance, or that clearly represent irreversible mucosal disease or osteitic bone, have been removed. Therefore, there is no routine surgical procedure. Typically, the dissection is begun anteriorly by removing the uncinate process, since inflammatory disease is most frequently present in this area. However, in some cases the operation could consist only of resection of the lateral half of the middle turbinate, as in the case of a concha bullosa with very limited disease. If the disease is confined to the frontal sinus, only an anterior ethmoid bone-frontal recess dissection will be performed. Similarly, if the disease is primarily in the maxillary sinus, an infundibulotomy and antrostomy may be all that is required. In contrast, FES does not imply limited surgery. When diffuse disease is present, as in diffuse nasal polyposis, the operation is continued until a complete sphenoethmoidectomy has been performed and the frontal and maxillary sinuses have been opened. Since the concept of FES is born out of meticulous diagnosis and the identification of an underlying cause of sinus disease, the benefit of this technique is maximized when a limited underlying cause can be identified for extensive disease. An example of an ideal case would therefore be an extensive frontal sinus mucocele in which a limited obstructive cause can be identified within the frontal recess. In this situation, it may be possible to minimize patient morbidity, performing a limited anterior ethmoidectomy as an outpatient procedure under local anesthesia.

Sphenoethmoidectomy under endoscopic control, however, is more akin to traditional intranasal ethmoidectomy (Wigand, 1981; Wigand et al, 1978). An initial partial resection of septal cartilage and bone is usually performed prior to beginning ethmoidal resection. The posterior one third, or in some cases all of the middle turbinate, is resected. The sphenoidal sinus is identified and opened, and a sphenoethmoidectomy is performed from a posterior to an anterior direction using a head light or microscope. Endoscopic visualization is introduced only when the gross disease has been resected and the major anatomic landmarks have been identified. Using a wide-angle telescope (30- or 70-degree) and a suction irrigation device, the residual disease is then removed. The area of the frontal recess is cleared of disease, the maxillary sinus is opened and disease is removed, and the cavity is given a final cleaning under endoscopic control.

Meticulous removal of maxillary or frontal sinus disease is not the aim of either endoscopic surgical procedure. The concept is to re-establish ventilation and mucociliary drainage and then to maintain them with careful postoperative medical treatment and local care. In this situation, the secondary disease in the major sinuses will frequently resolve, and the need for direct surgical intervention in the major sinuses is minimized.

Although ethmoidectomy under endoscopic control is usually performed under hypotensive general anesthesia, FES is usually performed under local anesthesia with meticulous atraumatic technique. Thus, bleeding is minimized by careful vasoconstriction and meticulous tissue handling techniques. The operation is performed from an anterior to posterior direction, typically beginning with the removal of disease from the ethmoidal infundibulum. Since sinus disease usually begins within the anterior ethmoid bone, unnecessary resection of the septum, middle turbinate, and posterior ethmoid bone is thereby avoided. The 0-degree telescope is employed from the very beginning of the procedure, using the magnification to avoid mucosal trauma. When more than a limited procedure is required, the medial orbital wall and the roof of the ethmoid sinus are identified and used as landmarks. If the skull base cannot be safely identified anteriorly, as in the case with severe disease, it is identified posteriorly within the larger posterior ethmoidal or sphenoidal sinus. Suction irrigation devices are not used, as they are larger and less delicately handled and are therefore more traumatic. Telescopes with deflected angles of view (30- and 70-degree) are used only for surgery within the recesses, as the 0-degree telescope is considered safer for routine use whenever possible. With FES, packing is generally avoided in order to decrease patient morbidity and enable early postoperative cleaning of the operative site.

The functional approach was born out of Messerklinger's meticulous studies of mucociliary clearance and of the pathophysiology of inflammatory sinus disease. The approach has the advantage of preserving a more normal nasal physiology and anatomy. The technique stresses detailed diagnostic assessment and combines current knowledge of pathophysiology with the advantages afforded by the use of endoscopes in order to reduce surgical morbidity. The approach is, therefore, becoming more generally accepted.

Discussion

The use of endoscopes during surgery on the paranasal sinuses improves visualization, enables greater preservation of normal structures, and reduces the necessity for wide exposure. Compared with the use of a head light or microscope, illumination and visualization are improved but, perhaps more importantly, the deflected angles of view enable the evaluation and removal of disease from recesses that could not be seen previously.

However, it must be remembered that the most significant advantages of FES do not lie in using telescopes at surgery. Rather, the most significant advances result from the improved diagnostic ability and understanding of the pathogenesis of sinusitis made possible by the CT. Indeed, the use of endoscopes is technically more demanding that the use of a microscope and should be performed only by surgeons who are well familiar with the technique. Conversely, the lessons learned from meticulous diagnosis, improved understanding of anatomic relationships, and knowledge regarding the pathogenesis of sinusitis are also applicable to surgeons who do not perform FES.

The potential complications of this procedure remain the same as for intranasal ethmoidectomy (Kennedy, 1986). Additionally, since the telescope is advanced during the dissection, and the optical quality of the Hopkins telescopes is superb, it is easy to penetrate more deeply than is apparent by the endoscopic view. Although Messerklinger and Stammberger have been able to perform 4000 procedures in which the only serious complications were two cerebrospinal leaks and one intraorbital hematoma, the potential complications remain major, and high complication rates have been reported in less-skilled hands (Stammberger, 1987; Stankiewicz, 1987).

The single most important concept is that the procedure must be performed under direct vision. Minor bleeders during the procedure may be tamponaded with a vasoconstrictive pack or hemostatic sponge. However, it is essential that if bleeding occurs to an extent that adequate visualization is no longer possible, the procedure should be terminated. Subsequent reoperation, if necessary, may then be performed either endoscopically or by an external approach.

The most likely sites for intracranial complications appear to be the roof of the ethmoid bone immediately posterior to the ethmoidal dome, and the posterior ethmoid bone anterosuperior to the sphenoidal sinus. If bleeding occurs during dissection high in the anterior ethmoid bone, it should be assumed that the skull base has been reached in the region of the anterior ethmoidal vessels, until proved otherwise.

Careful postoperative care and meticulous cleaning of the cavity are of major importance to the final surgical result. The cavity is cleaned under endoscopic control until it is healed and mucociliary clearance has been reestablished. Any adhesions that tend to form between the middle turbinate and the lateral nasal wall are divided at this time. Typically, antibiotics are administered during the perioperative period and, if necessary, they are continued for an extended period postoperatively. Oral or topical steroid therapy is administered as indicated.

In the functional approach, the natural ostium of the maxillary sinus is opened when stenosis is present. This approach has two significant advantages. First, it allows the removal of the adjacent ethmoidal disease that is almost inevitably present, and second, it enables the restoration of normal mucociliary drainage. Hilding's animal experiments (1950) suggested that infection or complete stenosis might result from mucosal trauma in this area. However, this has not been the result in our series. Longer follow-up also suggests that stenosis is a rare occurrence and is markedly less than with an inferior meatal window (Wilkerson, 1949; Lavelle, 1971; Kennedy et al, 1987b).

Similarly, in frontal sinus disease, therapy is directed toward removal of disease in the frontal recess of the ethmoid bone under direct vision, rather than intervention in the sinus itself. Previous teaching has been against interference with the nasofrontal duct because of the potential for postoperative stenosis (Hilding, 1933). The term *nasofrontal duct* is, however, a misnomer. The concept of a duct providing drainage from the frontal sinus is no more accurate than it is for the maxillary sinus. Since the passage from the frontal sinus travels between pneumatized anterior ethmoidal structures, careful dissection of the frontal recess provides wide access to the internal os and frequently also to the frontal sinus itself. Occasionally, however, in long-standing untreated frontal sinus disease, the internal os of the frontal sinus may become stenosed. In this situation, it is our preference to reapproach the sinus through an osteoplastic flap. Wigand, in contrast, drills away the bone of the anterior portion under endoscopic visualization. The mucosa of the os is preserved posteriorly, and the results are apparently good (Wigand, 1981).

The definition of what constitutes reversible mucosal disease following the restoration of normal drainage and ventilation remains to be fully defined. However, there seems to be a general trend toward greater conservatism in the removal of diseased mucosa, perhaps in part as a result of increasing recognition of the complication rate associated with Caldwell-Luc procedures (Buiter, 1982; Alusi, 1980; Murray, 1983). Carefully controlled long-term studies will be required to further evaluate this aspect, and the endoscopic technique is ideally suited for such purposes.

Functional endoscopic techniques offer the possibility for the resolution of medically unresponsive sinus disease, with minimal trauma to the normal structures and reduced morbidity. The key is the accurate diagnosis and removal of the underlying causes of sinus disease. A considerable time investment is therefore necessary in order to learn to identify the potential significance of the wide anatomic variations and to identify ostiomeatal inflammation. The lessons learned from improved diagnosis have resulted, and hopefully will continue to result, in better understanding of sinus disease.

The concept of meticulous diagnosis is equally applicable to medical therapy, as are improving accuracy in the evaluation of postsurgical results and decision-making regarding other operative procedures. It may be anticipated, therefore, that although endoscopic intranasal surgical techniques may not, and perhaps should not, be adopted by all surgeons, comprehensive nasal endoscopy will increasingly become the standard of care in the diagnosis of nasal and sinus complaints.