Endoscopic Surgery of the Paranasal Sinuses and Anterior Skull Base

Malte Erik Wigand

with the collaboration of W. Hosemann

and contributions by M. Brandl and M. Weidenbecher

Translated by P. M. Stell

Foreword by David W. Kennedy

Georg Thieme Verlag Stuttgart - New York
Foreword

This is a book that has been eagerly awaited by many otolaryngologists. It is a comprehensive and beautifully illustrated work by one of the recognized pioneers and leading experts in this field. Professor Wigand carefully documents the changes which have occurred in our concepts regarding the pathogenic mechanisms and treatment of chronic sinusitis. The difficult regional anatomy is presented in an organized fashion with sections on endoscopic, radiologic and cadaver anatomy. Each section is meticulously illustrated.

In addition to presenting both the anteroposterior and posteroanterior surgical approaches, Professor Wigand discusses endoscopic surgery for lesions of the anterior skull base, tumors, and dacryocystorhinostomy. He highlights the importance of careful endoscopic follow-up and postoperative care when surgery is performed for chronic inflammatory disease. He also details the results obtained in over 10 years' experience at the Erlangen University Clinic.

Some years ago I had the opportunity to visit Professor Wigand and to scrub with him in the operating room. As soon as he began the first case, it was obvious that I was in the presence of a master. As I have gotten to know him better, my initial observation has been reinforced. He approached that first case with meticulous atraumatic technique and clear knowledge of the anatomy, and maintained excellent hemostasis throughout. He has written this book with the same attention to detail. However, perhaps more importantly, he brings to his book a wealth of personal experience, the salient points of which are carefully elucidated in his writing. The advent of this book is a significant milestone in the field of sinus surgery.

David W. Kennedy, MD, FRCS.
Associated Professor
Departments of Otolaryngology - Head and Neck Surgery and Neurosurgery
The Johns Hopkins Medical Institutions
Baltimore, Maryland.
Preface

"To be successful, intranasal operations must be so designed as to restore the normal physiologic function of the nose. It is impossible with impunity to operate upon the interior of the nose as though it were simply an air flue and on the sinuses as though they were boxes."

Anderson C. Hilding, 1950.

Eleven years ago we gave our first report of the advantages of endoscopy in intranasal surgery (Wigand and Steiner, 1977). Now we feel able to produce a comprehensive account of this theme. This technique was originally thought to be merely a modification of the long-established procedures for the treatment of inflammations of the paranasal sinuses, but this view had to be rapidly adapted to changing views of the pathological and regenerative processes of the respiratory mucosa. The established surgical principle "where there is pus let it out" is inadequate for this complex system of rigid epithelial surfaces with a highly organized self-cleansing system. Understanding of this system, of the importance of the mucociliary transport system discovered in the 1930s by Anderson C. Hilding and so beautifully illustrated in recent years with endoscopic films by Messerklinger and his colleagues, and adaptation to the many new concepts demanded time and scientific proof.

Experience has justified our initial optimism that even the most severely inflamed hyperplastic mucosa could recover after restoration of ventilation and drainage, and this has led to a general decline in radical surgery. Hosemann has shown that the concept of complete elimination of mucosa thought to be irreversibly damaged is no longer tenable. Furthermore, the good results of tympanoplasty for infections of the middle ear have supported our confidence in a similar resolution of the chronically inflamed air cells of the anterior skull, and have shown that the concept of a constitutionally determined biological mucosal inferiority (Wittmaack) is no longer valid. Nonetheless many interactions between microanatomy and the local immune responses and healing processes of the mucosa remain unexplained. It is difficult in the midst of continuing research to declare a technique "ready" for a book. It is clear, however, that this new method must now be propagated and taught, and we as authors must accept the fact that criticisms, corrections and further developments will be made by others.

We have deliberately avoided writing a surgical atlas. Good surgical results demand an understanding of pathophysiology and surgical anatomy, experience in diagnosis and surgical skill. Therefore the chapter on operative technique is only a limited part of the book, and perhaps not the most essential. Neither is this book intended as a compendium of all known operations on the nasal and paranasal sinuses, but is restricted to those procedures which have become established and taught at the Erlangen Clinic. Concentration on personally proven method imposes some limitations, but also guarantees wide application and reliability. A good example of this is the personal modification of septal correction. This monograph is not intended as a didactic operative atlas, but rather a handbook based on the personal views and experiences of the author. For this reason the very extensive literature on intranasal surgery of the paranasal sinuses is only referred to sporadically, and many techniques are not mentioned.
Despite numerous publications from many centers, intranasal endoscopy in the surgical management of chronic sinusitis remains widely unknown and neglected, probably because the nasal surgeon does not feel at ease working in a delicate anatomical region through narrow access. Even until recent times intranasal ethmoidal surgery has been regarded as being fraught with complications, including severe hemorrhage, blindness and intracranial infection. It must be emphasized that these fears are much less with experienced endoscopic nasal surgeons. If the jaws of the instrument can no longer be seen by the naked eye, and working distances and the direction of dissection are difficult to estimate, then naturally the procedure is unsafe. Safe dissection demands thorough study of endoscopic anatomy, and practice of endoscopic manipulations with both hands. It is hoped that the results given in Chapter 7 will be proof of this. The last section of the chapter on operative techniques shows that the range of indications has been extended to include surgery of the anterior base of the skull, and of obstructed lacrimal ducts, as described by Professor Dr M. Weidenbecher.

A wide range of illustrations is necessary to demonstrate all these procedures. Dr Hosemann has been particularly helpful with the organization of the material and recording of the operative steps on practice models. I am also very grateful to my colleagues Dr Burlein, Dr Kachlik, Dr Riemann and Herr Gerard for taking the endoscopic pictures, and for other photographs. I am very grateful to Herr M. Jauch of Richard Wolf (Kittlingen) for a series of diagrams to illustrate the use of the instruments.

Not all the operative steps could be illustrated on one specimen, so the figures had to be taken from various dissections. Since only one side of the nose is presented to give a better insight into endoscopic anatomy, many original figures had to be transposed.

I am particularly grateful to Professor Dr Brandl, and his many colleagues of the Institute of Anesthesiology (Director, Professor Dr E. Ruegheimer) of the University of Erlangen-Nuremberg for their contributions to general anesthesia for this form of surgery, for their patience and understanding and for providing a bloodless field.

I wish to thank my former colleague Professor Dr W. Steiner, now Director of the Department of ORL at the University in Goettingen, for his thoughtful and practical support in the early phase of our joint venture into this previously unknown field of endoscopy. I am also indebted to Professor Dr J. Lang, Director of the Anatomical Institute of the University of Wuerzburg, and to Dr M. P. Jaumann of Goeppingen for the loan of anatomical and endoscopic illustrations.

I would like to record my thanks to my secretary Karin Sippel for skilled assistance in the revision of the manuscript under difficult circumstances; sadly she died in July 1988.

Our librarian Beate Broghammer has worked tirelessly and carefully in accumulating the references, and on the input of data for the index as outlined by Dr Hosemann. I wish to express my sincere gratitude to her, both for the present work and for help with papers and courses over many years.

I am very grateful to my wife Monika Christina whose careful reading has eliminated many unclear points from the text, and who has compiled the index.
Finally I wish to express my thanks to Dr med L. C. G. Hauff of Georg Thieme for his untiring encouragement to write this monograph, and to Herr W. Tannert for the high quality which is characteristic of this publishing house.


Malte Erik Wigand

Acknowledgment

It is my privilege to express both my gratitude and appreciation to Prof Philip M. Stell, Liverpool, who kindly took on the task of translating this book into current medical English. The text was reread by Prof Stanley E. Thawley, who added special terms used in the United States, where endoscopic sinus surgery has become very popular during recent years. I am very grateful to both Prof Stell and Dr Thawley for their careful work.

February 1990.  

Malte Erik Wigand
1. Concepts of Intranasal Surgery of the Paranasal Sinuses

Intranasal endoscopic surgery of the paranasal sinuses is mainly indicated in the management of chronic sinusitis. It is based on entirely different concepts from those of radical surgery, and several prerequisites must be fulfilled if this alternative to the classical operations is to succeed. Intranasal procedures on the paranasal sinuses were first developed about 100 years ago, but were quickly abandoned because of uncertain results and frequent complications. Intranasal surgery of the paranasal sinuses has undergone a renaissance in the last decade, due to many technical advances and improved understanding of the biology and clinical behavior of sinusitis.

This change is based on the following:

- modification of long-standing concepts of mucosal pathophysiology,
- a more thorough knowledge of topographic anatomy,
- adaptation to endoscopic operative techniques using special angled telescopes and instruments through a narrow access,
- abandoning cherished principles of en-bloc clearance via wide access,
- a long-term treatment plan that includes supplementary procedures and time-consuming endoscopic aftercare, which the patient must accept as an important part of the treatment.

Attention to the details of this complex treatment strategy is needed to reap the full benefit of intranasal surgery, to avoid complications and disappointing results, and to recognize the unsolved problems obstructing the development of ideal treatment.

The local patho-histomorphological appearance of the mucosa in one sinus does not reflect the actual stage of the disease in other compartments.

Surgical Pathology of the Sinus Mucosa

The respiratory mucosa of the nose and paranasal sinuses does not present a homogenous histological structure throughout its extent. Its texture depends on site, age and physical/biological responses to metabolic, endocrine and other factors.

In the nasal cavity, secretory elements (goblet cells and mucosal glands) are abundant where the mucosa carries a dense ciliary layer. In the more remove niches of the large sinuses these typical characteristics are sparser, and the histological picture more nearly resembles that of a mucoperiosteum with, at times, a thin serosal layer resembling the pattern of the middle ear and mastoid. Tos et al (1978) have measured accurately the normal variation in density of the mucosal glands in the sinuses: under pathological conditions this pattern of distribution can change radically. The frequent macroscopical variants of the mucosa, even in the absence of inflammation, are already familiar to the rhinologist: dry, thickened regions at the nasal valve, atrophic areas over bony ridges, succulent velvety ends of the turbinates with arterial, or venous coloration, and finally the swollen, pale mulberry-like, bluish-red colored mucosa on the posterior end of the turbinates.
The local appearances of the mucosa show even more marked variations in sinusitis. The endoscopist is familiar with the various swellings, edematous areas, papillary hyperplasia and polyps that differ between the two sides and even within one nasal cavity. Using standardized mucosal biopsies Hosemann (1985) has demonstrated the wide variation in histopathology of sinus mucosa in diffuse polypoid hyperplastic sinusitis. A diagnosis of sinusitis by the histopathologist does not apply to the entire mucosa but only to that part which is sampled. This conclusion is self-evident, but conflicts with the concept of radical surgery that demands complete mucosal clearance.

In our experience temporal factors are as important as local factors because histomorphological findings change enormously over time. After a successful tympanoplasty even the most severe mucosal lesions have often regressed when the ear is later re-opened after aeration and internal drainage have been restored. A previously very hyperplastic layer will be found to have been replaced by non-inflamed, soft mucosa. The same results have now been found many times after surgery for severe sinusitis with mucosal preservation: even previously thick, spongy, injected and indurated mucosa presents a completely healthy appearance after conservative sinus operations that restore drainage and aeration. Thus neither the surgeon's eye nor the results of a frozen tissue section can predict whether inflamed mucosa is capable of resolution.

At the time of a first operation the surgeon can by no means predict whether the chronically diseased mucosa will recover or not.

**Mucositis**

Little is known of the morphological and functional changes in acute and chronic inflammation of the respiratory mucosa or of the healing processes, either with or without surgery. Numerous histomorphological and structural investigations have been done of the mucosal response pattern, the lymphatic system and the pathological ciliary activity of the mucosa of men and animals (eg, Naumann, 1961, Jahnke, 1972, and Terrahe, 1970), but an overall view of nonspecific mucosal inflammation is not available. The temporal course of the phenomena associated with spread of inflammation from the nasal cavity into the sinuses is not known.

We suspect that an intermediate stage of hyperaemia, lymphatic swelling, stasis in the blood and lymphatic pathways, and increased secretion of mucus succeeds an initial stage of hyperemia with reduced mucociliary transport. This is followed either by resolution or by progression to a chronic stage with pathological increase in the elements of the lamina propria such as cells, fibers and ground substance, and resultant permanent disruption of the mucociliary transport and lymphatic drainage. The resulting obstruction of the narrow ducts between the paranasal sinuses and the nasal cavity leads to a vicious circle of retention of secretions, obstruction of lymphatic drainage, edema, and finally organized connective tissue and mucosal hyperplasia. The causes of local and temporal variations of pathology probably depend on anatomy, the local mucosal response, the influence of other body systems, pathogens and on external noxious agents. The factors which influence spontaneous recovery of the inflamed mucosa and determine its remarkable regenerative capacity even though it has been diseased for many years, remain unknown.
Polyps, retention cysts and fistulae do not have a high potential for recovery, so that removal of mucosa should be restricted to these lesions, whereas smooth swellings, cushions of edema and areas of papillary mucosa can be preserved and given the chance to recover. It is uncertain whether polyps and retention cysts in children heal spontaneously.

In sinusitis, the removal of mucosal lesions which appear to be incapable of resolution is limited to polyps and (pseudo) cysts. Flat edematous swellings and broad-based mucosal cushions can be preserved. The treatment of granulations follows the principles of the treatment of ulcers (see below).

Doctors and patients often ask whether the chance of healing is reduced by allergy, particularly of the respiratory, immediate type. Basically, it is not: data in the literature about this question are scarce, and the conclusion is based on only a proportion of patients because it is impossible to subject a large number of subjects to complete allergy tests including all possible provocation tests before and after operation.

About 10% of the population including those with chronic polypoid sinusitis demonstrate an allergic response, and eosinophilia is often found in polyps. These two facts have led to overestimation of the importance of Type I allergy in the genesis and prognosis of nasal polyps. However, tissue eosinophilia is also found in primary non-allergic rhinitis, a disease which is often combined with endogenous asthma and sensitivity to analgesics. Furthermore, the typical immune reactive elements, such as eosinophilia, plasma cells and immunoglobulin deposits, are so varied that local mucosal individual responses must be recognized. In vitro experiments after a challenge with allergens showed no difference in the basic histamine release of polyps from allergic and non-allergic subjects (Baenkler et al, 1983, 1987).

There is no correlation between the histological and immunohistochemical findings and the clinical and immunological response of patients with severe polypoid sinusitis (Waller et al, 1976). This fact is borne out by the smooth healing independent of proven allergy.

Whereas antiallergic conservative treatment of patients with nasal polyps can obviously lead to some reduction in size of the polyps, on account of reduction of the edema it is not adequate long-term therapy. In the author's own follow-up investigations after intranasal ethmoid operations the results of the operation did not depend on respiratory allergy or on treatment by desensitization. Surgery influences the allergic mucosal response favorably by controlling the inflammation, and often leads to complete or at least considerable relief of symptoms. Supplementary measures, for example septal correction, also play a role in this process.

**Surgical Principles**

The main goal of intranasal endoscopic surgery for chronic sinusitis is the maximal preservation of mucosa achieved by restoration of drainage and ventilation. This principle stands in marked contrast with radical surgery in which mucosa regarded as irreversibly damaged or as "biologically inferior" is completely removed and the bony framework is also widely sacrificed. In this surgery, for instance, the maxillary sinus is deprived of its rigid anterior wall so that the facial soft tissues can prolapse, and the upper jaw may later shorten.
due to scar tissue contracture. Also much of its medial wall is lost if a large window is created into the inferior meatus through which a flap of nasal mucosa is turned. The external frontal and ethmoid operations also change the bony structures of the frontal infundibulum and anterior ethmoid decisively. Mucosal flaps are often turned in to prevent the penetration of scar tissue into this sensitive area, but they do not always ensure aeration, and mucoceles can arise later.

Intranasal endoscopic surgery has two goals: maximal preservation of all living mucosa, and a secure communication between the nasal cavity and the paranasal sinuses via the natural channels. In the maxillary sinus the latter is achieved by creation of a new window in the middle nasal meatus, complemented if necessary by an inferior meatal antrostomy, without reflection of a flap of nasal mucosa whose direction of ciliary stream is unknown, and without distortion of the bony anterior wall. In the frontal sinus the aim is to restore ventilation and drainage into the nose via the original frontonasal duct or a channel of maximal width but not by weakening of the bone around the infundibulum.

The same concept also applies to the ethmoid and sphenoid sinuses: of necessity many cells must be removed, but not every cell must be denuded or drilled out into every last corner. Only the narrow points are opened up in “isthmus surgery. The improved aeration and drainage and supplementary procedures (see below) can be confidently expected to achieve permanent resolution of the chronically inflamed mucosa. The entire circumference of ducts and antrostomies must not be completely denuded of mucosa as this leads to stenosis.

Mucosal continuity of the sinus cavities with each other and the nose is important, to restore mucociliary transport, to prevent granulations arising from denuded bone, and, more importantly, to supplement the abnormal or absent lymphatic drainage. Although this matter has received little attention, the author's own endoscopic dissections show that the diversion or abnormal function of the lymphatic network can cause serious problems. Even minor manipulations at the ostium or in a duct can lead to long-standing mucosal edema within the sinus interfering with healing as much as disordered mucociliar transport.

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.

The recommendation to open narrow areas should not be interpreted as an invitation to create large cavities: respect for natural sinus physiology is the guideline running through this type of surgery. On the other hand, the long-held view that wide nasal cavities automatically carry the danger of drying and atrophy of the mucosa, and even of ozena, must be challenged. Despite relatively generous septal correction, partial resection of the middle turbinate with complete ethmoidectomy (see below) and limited inferior turbinectomy, we have so far seen not one single case of true ozena after intranasal ethmoidectomy. Although poor aftercare can cause crusting in the ethmoid sinuses, careful removal of the crusts reveals that the underlying mucosa is not dry and atrophic but oversecreting with resultant granulations.

Enlargement of the nasal cavity by ethmoidectomy, partial turbinectomy, and septum correction does not provoke atrophic rhinitis.
Healing Problems

The preceding goals are often not achieved: exact resection of bone, and precise removal of mucosal lesions are often not accomplished for the lack of suitable instruments, leading to the creation of unnecessarily large mucosal defects that heal by scar tissue. Remote ethmoidal cells may be hidden from inspection and remain unopened, and they can stimulate recurrent ethmoiditis. Also, some obstructions to drainage can be overlooked. However, at every point where bone has been denuded new mucosa must grow over a granulating intermediate layer before healing can be expected. The outcome is jeopardized by three factors: failure of reorganization of mucociliary transport, excessive granulations and abnormal lymphatic drainage.

From every mucosal defect can arise granulation tissue preventing mucosal regeneration. The resulting scar tissue distorts mucociliary transport and lymphatic drainage which can produce retained secretions even in an open sinus cavity.

Textbooks of general pathology and general surgery fail to mention the spontaneous healing of defects of the respiratory mucosa. Little is known of the inflammatory reaction, the speed of formation of replacement tissue in mucosal ulcers, the proliferative power of the underlying bone and its peristome or of the edges of a mucosal defect, and whether metaplasia is to be expected as an intermediate stage (Lenz and Preussler, 1986). Few histological investigations have been performed which evaluate the influence of medical treatment on the local healing of defects of the respiratory mucosa.

The physiological transport pathways can be seen applying particles to the mucosa of live or dead animals and observing the particle movement (Hilding, 1932, Proetz, 1941, Messerklinger, 1960). However, it is not known whether the pathways regenerate following inflammation and/or surgery, or whether regenerated mucosa incorporates mucociliary action. The importance of replacement mechanisms, such as expulsion of secretion by pressure changes during breathing is also unknown. Hosemann (1985) used photography to show that carbon particles placed on the floor of the maxillary antrum are transported upwards over the maxillary walls and through the antrostomy into the nasal cavity after either an inferior or middle meatal antrostomy. Also, he showed by endoscopy that secretions drain continuously through a newly created antrostomy, and that the edges of the antrostomy are covered by ciliated respiratory epithelium. It is uncertain how this phenomenon is restored in the frontal infundibulum, the ethmoid niches and the sphenoid sinus, and how mucus, bacteria, etc, are transported. The basic studies of mucociliary transport carried out by Hilding (1932, 1941) were the first to show that mucus and particles were moved along preordained corkscrew pathways to the ostia by the coordinated ciliary beat of the respiratory epithelium. New windows in the wall of the maxilla are bypassed, and the transport pathway can even carry the particle out of the cavity and then back in again at the opposite edge of the antrostomy. Hilding showed that ridges of scar tissue can easily arise in a hollow organ forming an insurmountable barrier even if their height is minimal. He showed also that collections of mucus can be carried along by neighboring mucociliary epithelial activity, so that cleansing of mucosal surfaces with no ciliary activity can still be achieved. The concept of minimal injury to the mucosa during endoscopic surgery developed from this insight. In particular the formation of a ridge of scar tissue is to be avoided.
Data in the literature about reversal of the direction of the ciliary beat after transplantation of the mucosa are contradictory. The possible serious disadvantages following the rotation of mucosal flaps (Uffenorde or Boenninghaus) or free transplants of mucosal islands (Wigand) is ignored in practice.

Excessive granulation tissue in surgically created mucosal defects is even more important because of the resultant obstruction of narrow ducts, outflow tracts or neighboring mucosal niches. The race between formation of new granulation tissue in a vertical direction, and re-epithelialization in a horizontal plane is a well known phenomenon in cutaneous wound healing. Slowly-healing ulcers can usually be controlled by superficial cautery with a silver nitrate stick because the squamous epithelium can grow more readily over the flat fresh wound. This healing process has not been investigated satisfactorily in the respiratory mucosa.

Endoscopic study of healing shows that the shape of the wound surface influences the healing of the ulcer. The concave gutters in the anterior ethmoid, the antrostomies and ducts are ideal sites for the formation of granulation tissue which is converted to scar tissue by the normal contraction of collagen fibers, leading to restenosis and polyp formation. This epithelialized granulation tissue, like the middle-ear polyp, must be distinguished from the true edematous mucosal polyp. Obstruction of the anterior ethmoid and the frontal duct by scar tissue or by a granular polyp is a common cause of recurrent sinusitis after ethmoid operations. To what extent the shape of the "concave ulcer", and obstruction to aeration by the agger nasi, the nasal septum or other factors such as disorganized mucociliary transport are responsible for this common cause of failure is unknown. Systemic factors such as allergy, immune deficiencies, exogenous toxins, etc, must be taken into account, but local biomechanical causes also need attention during the postoperative phase.

If a surgeon finds that the polyps often arise in the anterior ethmoid area after sphenoethmoidectomy, whereas the posterior ethmoidal walls and the sphenoidal cavity heal, then he should ask the following questions:

- have the anterior ethmoid cells been completely exposed?
- has unsatisfactory resection of the agger nasi created a narrow pit which is inefficiently aerated?
- is the anterior ethmoid gutter narrow due to an uncorrected upper nasal septum?
- are all cells and niches open and draining properly; this can be assessed reliably by high resolution CT scan.

Supplementary Procedures

Healing of chronic sinusitis is not ensured by an endonasal procedure: all factors contributing to the pathogenesis demand attention. The history, examination and investigation should reveal the severity and extent of the mucosal disease, and explain its cause (see Chapter 3). Operative clearance of the affected sinus should be paralleled by treatment of the suspected causal factors (Table 1.1). These factors may be neglected because the surgeon concentrates on the visible disease, and underestimates the influence of neighboring tissue and of systemic factors.
Table 1.1. Accessory procedures for operative treatment of sinusitis

- Normalization of ventilation of the nose and sinuses (correction of septal deviation or cleft palate, turbinectomy, adenoidecomy, tonsillectomy).
- Elimination of septic foci (dental attention, tonsillectomy, elimination of exogenous toxins).
- Treatment of systemic disorders (such as allergy, immune deficits, hormonal disorders, mucoviscidosis, etc).

A common cause of chronic sinusitis is abnormal ventilation of the nasal cavity and the ostia of the sinuses. Whether abnormal ventilation and obstruction to drainage play an equal part, or whether the disorder of drainage is due to the deficient aeration is unknown. Endoscopic findings, and possibly rhinomanometry, indicate whether a *septal correction or reduction of the turbinates* is indicated. The decision to carry out seoptoplasty cannot always be based on the patient's symptoms, such as nasal obstruction, or on objective data provided by rhinomanometry. It is frequently based on consideration of the pathogenesis of the sinusitis, such as pronounced narrowing of the middle meatus by a septal spur. Also a free exposure for the operating instruments and for the postoperative manipulation has to be calculated. A septum which has previously been operated on, a perforated septum, narrow nostril due to a wide *columella*, or nasal *alae* which are too lax and prolapse on inspiration may need to be corrected. In children, enlarged tonsils or adenoids are potential causes of obstruction to breathing or drainage and their removal often cures chronic or recurrent sinusitis in children, without any further procedure being necessary.

The effects of *congenital clefts* and their surgical repair are difficult to evaluate. Chronic sinusitis is encouraged by displacement or widening of the septum, and elevated floor of the nose, and anomalies of the soft palate. Thus reconstruction of the floor of the nose or the soft palate may be needed for functional reasons. It is more important to look for a dental cause of inflammation of the sinus mucosa such as a *root abscess* and a dental consultation is often advisable. Reports of the frequency of dental disease vary widely. Since the dentist is often unable to find a focus in the dental roots to explain mucosal proliferations on the floor of the antrum, it may be possible that periodontal mucosal disease alone can lead to circumscribed areas of osteitis with resultant sinusitis. Polyps on the floor of the antrum often lie very close to a conserved molar or premolar even if their roots do not appear to be disease or visible within the antral lumen.

A proven dental cause for the sinusitis does not demand transoral opening of the sinus. Dental treatment combined with endoscopic management of the sinuses fulfills the same purpose, and avoids the well known disadvantages of the Caldwell-Luc operation.

Other *exogenous agents* which should be eliminated include:

- inhaled industrial irritants,
- cigarettes and snuff,
- side effects of drugs.
The treatment of *allergy* before and after operation should also be mentioned. However, operative correction of narrow areas of the nose and/or the sinuses cannot be replaced by treatment of the allergy. Surgery should be carried out if indicated on its own merits, even in patients with sensitivity to aspirin, or in those with *endocrine diseases*.

Surgery may also be useful for *systemic diseases* in childhood such as mucoviscidosis. Previously, surgery to the sinuses in these cases was thought to be useless or even harmful, but pediatricians now find increasingly that surgery to the sinuses improves the course of asthma, bronchitis and mucoviscidosis. The main contraindication to surgery is not the difficulty of the operative technique in the small sinus system, or reduced healing ability, but the inability of children to tolerate the essential endoscopic aftercare. Close cooperation with neighboring disciplines such as pediatrics, pulmonology and immunology is important in achieving a good result from intranasal sinus surgery in children.

**Endoscopic Aftercare**

Endoscopic postoperative care is important for the success of endoscopic sinus surgery. Even patients who have undergone a minor procedure such as antrostomy, removal of a cyst, etc, benefit from follow-up for a few weeks to allow the sinuses to be irrigated, secretions to be removed by suction, adhesions within the antrostomy and nasal ducts or between the turbinate and the ethmoid wall to be divided and granulations at the wound edge to be cauterized. These steps are even more necessary after ethmoidectomy for profuse polyposis or other diseases. It can never be assumed that recovery and regrowth of the mucosa will proceed smoothly and spontaneously. The guidelines (Table 1.2) for aftercare described below rely more on intuition and experience than on a scientific basis, and need basic investigation. Follow-up may be needed for up to 2 years.

**Table 1.2. Methods for endoscopic aftercare following surgery for chronic sinusitis**

- Removal of crusts and clots.
- Cautery and removal of granulations.
- Division of synechiae.
- Treatment of infection by antibiotics.
- Treatment of edema with inhalations and steroids.
- Elimination of causative factors such as allergy, immune deficits, etc.

**Acute Postoperative Phase**

Clots and crusts often cause renewed obstruction of the nasal passages after the nasal packing is removed on the second day after operation, and require careful suction once a day to guarantee nasal patency. In this phase the inhalation of a saline solution increases the fluidity of fibrin clots and crusts. Prophylactic antibiotics are usually given, preferably a broad-spectrum agent such as doxycycline which penetrates the mucosa well. Swelling of the septal and turbinate mucosa should be treated by nonsteroidal anti-inflammatory agents. Allergic and asthmatic subjects may need temporary treatment with systemic corticosteroids, because of their superior effect in comparison to sprays and nasal drops.
After a few days when the acute danger of reactionary hemorrhage has passed, the all
important narrow areas - the frontal duct, the superior ethmoid gutter, the sphenoid cavity and
the antrostomy - are cleaned by daily endoscopy. The middle turbinate should be replaced in
its correct position using a slightly curved suction tube or a curved elevator to prevent it
swinging laterally and adhering to the lateral nasal wall in the absence of the supporting
ethmoid cells. Mechanical trauma to the mucosa must be avoided. Irrigation with saline
solution or installation of gel solutions mixed with antibiotics and steroids into the frontal
antral cavities are useful.

The patient is soon able to dissolve the crusts for himself with saline irrigation several
times a day, and by repeated inhalation of antibiotic solutions. A double inhalation
supplemented by Tacholiquin (Tyloxapol) and Nebacetin (neomycin plus bacitracin) solution
has proved useful for persisting suppuration.

Massive edema of the remaining antral or ethmoid mucosa is found in many cases a
few days after the operation, particularly at the edges of the wounds or the antrostomy. It is
not clear whether this is due to inflammation or to lymphatic stasis. *Cushions of edema* can
be very persistent and lead to recurrence of edematous pseudocysts and polyps. At the same
time *granulations* often spring from the bony wall which has been denuded of mucosa.
Endoscopic incision or cauterization with 10-20% silver nitrate is used in an attempt to
suppress these swellings which can obstruct the narrow areas and lead to a vicious circle.
Short courses of systemic steroids are often helpful. Occasionally the initial tendency to
crusting can be suppressed by loose daily packing of the ethmoid cavity with gauze strips
soaked in aureomycin. Crusting should never be interpreted as indicating mucosal atrophy:
it is caused by secretions drying out on ulcerated or overreactive mucosa. The old
dermatological principle of "treat moisture with moisture" is also valid in this situation.

**Late Postoperative Phase**

If excess, possibly purulent, secretion is a prominent feature in the early healing phase,
the wound will form profuse granulation tissue 3-4 weeks later, demanding even more careful
endoscopic control and energetic countermeasures. The sites of predilection for granulation
tissue are the edges of an antrostomy, a sphenoidectomy, or the edge of the frontal duct.
Often in this stage the middle turbinate tends to abut against the lateral ethmoidal wall
because it has lost its support, and the anterior ethmoid gutter is obstructed if the turbinate
is not replaced in its correct position. Endoscopic attention to this site of obstruction ensures
freedom from crusts under which fibrin adhesions can develop to be followed rapidly by
synechiae. Small granulation tissue polyps must be distinguished from edema of the mucosal
edges; they may be cauterized with 10-20% silver nitrate. Adhesions can be divided easily
with the scissors, the cutting diathermy or the laser, but sheets of scar tissue require revision
surgery. Revision surgery is particularly valuable if the sense of smell can be restored by
reopening of the olfactory cleft, or if inflammation of the mucosa of the frontal sinuses
resolves after a second-stage, wider opening of the frontal duct.

This phase of reparative granulations and scar tissue formation can last for several
months. Healing is complete and the danger of scar formation obstruction is past only when
complete re-epithelialization by respiratory mucosa or by metaplastic stratified epithelium is
complete. However, if wound healing is left to its own devices there is a danger of stenosis
of the antrostomy or closure of the narrow outflow tract of the frontal sinus and the upper ethmoid gutter.

This period is often also marked by recurrence of the symptoms of asthma or bronchitis. It is suspected that breakdown products of bacteria and secretions become noxious due to renewed stasis in the cell recesses and hollow niches. A pre-existing hypersensitivity of the bronchial mucosa may worsen, precipitating an attack of asthma, by neural reflexes, or by intraluminal or hematogenous spread of toxins or allergens. Recovery can be achieved in these cases by reopening the narrow areas, either by cautery of the bands of scar tissue as an outpatient, or by curettage under surgical conditions.

Before the first operation the patient with severe polyposis must be warned of the difficulties of the postoperative phase, and be prepared for the program of aftercare during which further surgery may be necessary. This applies particularly to children who need a general anesthetic for effective endoscopic procedures. The surgery should be supplemented by conservative methods such as drugs, sprays, nasal emulsions, etc, dictated by the surgeon's personal experience.

**Maintenance of the Olfactory Cleft**

Chronic rhinosinusitis extends to much of the mucosa of the olfactory area. Superficial swelling of this area causes intermittent or permanent dysosmia. Polyps seldom form in the superior and supreme nasal meatus: they consist of granulation tissue and sometimes of edematous mucosa, and are caused solely by injury to the mucosa of this region. This fact should be remembered in surgery of the nose and ethmoid sinuses, even simple polypectomy, but particularly during ethmoidectomy. The mucosa should be preserved very carefully to prevent later closure of the olfactory cleft by granulations or scar tissue.

Sheets of silicone or similar material placed in the olfactory cleft, fixed to the septum by interrupted sutures are often useful, but cautery, curettage removal of tissue with the punch and the use of pressure should be avoided (see also reconstruction of the olfactory cleft during ethmoidal operations).

**Informed Consent**

Operations on the nose and sinuses require careful explanation to the patient. The legal system expects the surgeon to discuss typical dangers and rarer complications before the operation. In the author's experience the rhinologist can find himself in a dilemma: a too-wide ranging explanation can lead to unnecessary anxiety, and many patients are frightened off a necessary procedure.

It is advisable to record in the case sheet the dangers and results of the operation which have been discussed with the patient. When drawing up the operation notes it should be remembered that judges, administrators and the general public now expect that the case sheet be made available. This process may lead to an overly pessimistic description of the likely outcome of the operation. One can imagine that the scientific value of such reports may be reduced in the future.
The complications are determined by the neighboring structures which are in danger. After *endoscopy or operations on the antrum* these include:

- spread of inflammation to the mouth, jaw and cheek,
- disturbances of vision and lacrimal function,
- loss of sensation and neuralgia in the face and anterior scalp.

The complications of procedures on the ethmoid, sphenoid and frontal sinuses include:

- life-threatening blood loss, and bleeding into the cranial cavity,
- CSF leak with infection of the meninges and brain,
- dysosmia, leading to subjective changes in or loss of the sense of taste,
- defects of vision including blindness,
- infection of the skull base,
- pain and neuralgia in the face and head.

Secondly, it must be explained that the postoperative healing phase may last a long time. Patients often imagine that the disease will be completely relieved once they recover from the anesthetic because they have no postoperative pain, no suture line, no evidence of blood loss or external splints. It must be explained before the operation that an extensive internal organ was chronically inflamed and requires time, patience and tolerance of pain during the healing phase.

Thirdly, every surgeon must be able to answer questions about the likely outcome of the procedure. The author's results are summarized in Chapter 7.

**Basic Principles of Endoscopic Surgery of the Paranasal Sinuses:**

Advantages, Disadvantages and Outcome

Other specialists, such as urologists, internists, etc, introduce their instruments through the endoscope (transendoscopically). Some nasal surgeons, for example Draf (1978), prefer endoscopic manipulations of this type, but the author's bade experiences with the resulting limitation to the use of very small instruments led him rapidly to decide to use a para-endoscopic technique in which the endoscope is reserved for observation only. This option allows instruments of various curves, shapes and sizes, the laser, the cutting diathermy and other instruments to be used.

The binocular operating microscope has contributed so much to the development of ear, nose and throat surgery but has a very limited place in intranasal surgery because it does not provide angular vision allowing a view through antrostomies and into niches.

At the present time simple, rigid, angled telescope are used by many intranasal surgeons, but they rapidly become obscured by blood or secretions, and need repeated cleaning. Therefore an endoscope has been developed which keeps the eyepiece free by integrated suction and irrigation, and which also keeps the surgical field clear to some extent. However, further technical improvements are required to achieve even better use of the endoscope and special instruments, in particular better manipulation of the instruments alongside the endoscope. Furthermore, very precise removal of tissue is compromised by
damage to neighboring mucosa which is worth preserving: punches and forceps that cut rather than tear, must be developed. The ideal would be an effective cutting diathermy that produced no devitalizing thermal effects on the surrounding tissue.

Even without these desirable technical improvements, endoscopic sinus surgery can now be regarded as the optimal method for restoring paranasal sinuses that are free of scar tissue, have a healthy mucosal lining and normal physiology. With an experienced endoscopic surgeon, it is also safer than radical external surgery. Its advantages include:

- preservation of the bony contours,
- preservation of viable mucosal surfaces with precise removal of irreversibly damaged mucosa,
- preservation of neighboring structures by optical control of anatomical details,
- abolition of complicated flap procedures on the frontal and maxillary sinuses,
- lower postoperative morbidity.

It has the following disadvantages:

- the view into the nose is restricted, even if the septum is first corrected,
- the extent for manipulations is limited, particularly around a bony lesion whereas external access allows radical excisions to be performed,
- suturing, wiring, the use of screws, implantation or reconstruction of entire walls using allogenic materials or ceramics cannot be achieved by endoscopic methods; external exposure is necessary for such types of reconstruction.

Endoscopic intranasal surgery has a limited place in surgery of trauma or tumors of the paranasal sinuses and anterior skull base. However, there is a place for the combination of both procedures, for example dissection of the sinuses by an external approach with endoscopic monitoring or vice versa, so that the external, destructive access does not need to be as extensive as in the classical procedures. Similarly, in severe frontobasal or middle third facial fractures, the structures are better retained if the fracture repair is performed externally whereas the ostia and the cells are debrided endoscopically.