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*Clinical review*

# Functional endoscopic sinus surgery*

## Concept, indications and results of the Messerklinger technique

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**Summary.** The Messerklinger technique is a primarily diagnostic endoscopic concept demonstrating that the frontal and the maxillary sinuses are subordinate cavities. Disease usually starts in the nose and spreads through the ethmoidal prechambers to the frontal and maxillary sinuses, with infections of these latter sinuses thus usually being of secondary nature. Standard rhinoscopy and sinus X-rays are frequently not sufficient to demonstrate the underlying causes for chronic or recurring acute sinusitis in the clefts of the anterior ethmoidal sinuses. The combination of diagnostic endoscopy of the lateral nasal wall with conventional or computed tomography in the coronal plane has proven to be the ideal method for the examination of inflammatory diseases of the paranasal sinuses. In so doing, diseases and lesions that otherwise might have gone undiagnosed can be identified and consequently treated. Based on this diagnostic approach, an endoscopic surgical concept was developed, aiming for the underlying causes of sinus diseases instead of the secondarily involved larger sinuses. With usually very limited surgical procedures, diseased ethmoid compartments are operated on, stenotic clefts widened and prechambers to the frontal and maxillary sinuses freed from disease. In our experience, there is rarely a need for major manipulations inside the larger sinuses per se. Based on exact diagnosis, the surgical technique used allows a very individualized staging according to the prevailing pathology. In the extreme, a total sphenoethmoidectomy can be performed with this technique, although the true advantage of the technique is that even in cases of massive disease such radical procedures can be avoided. By reestablishing sinus ventilation and drainage via the natural ostia, there is also no need for fenestration of the inferior meatus. The Messerklinger technique can be applied to a wide spectrum of indications, apart from nasal polyposis. The technique has its clear limits as well as its specific problems. Adequate training and experience are required for the surgical approach, as the technique bears all the risks and hazards of all kinds of endonasal ethmoid surgery but has a minimal complication rate in the hands of an experienced surgeon. Results and complications of a series of more than 4500 patients over a period of over 10 years are presented and discussed in detail.

**Key words:** Functional endoscopic sinus surgery – Messerklinger technique – Results – Complications

* Dedicated to Professor W. Messerklinger on the occasion of his 70th birthday

*Offprint requests to:* H. Stammberger

### The concept

The so-called functional endoscopic sinus surgery (FES) is based on the clinical experience that most infections of the larger sinuses are rhinogenic: i.e., disease spreads from the nose to the paranasal sinuses. Although the clinically dominating symptoms may be due to disease inside the frontal or the maxillary sinuses, in most of the cases the underlying causes are not to be found in the affected sinuses themselves, but in the lateral nasal wall. There, normally very narrow clefts of the anterior ethmoid hold a key position for the normal function and the pathophysiology of the larger paranasal sinuses. They can be seen as "prechambers" of the dependent frontal and maxillary sinuses, providing ventilation and drainage for the latter. Many anatomical variants can stenose these prechambers even more and thus predispose these spaces to recurring infections [7, 10, 13, 14, 21–23, 28–30].

The development of a surgical concept aiming at the diseased areas in the ethmoidal prechambers instead of the secondarily involved larger sinuses was a logical consequence. When this technique replaced more radical sinus procedures in 1970, it was possible to see that even massive mucosal pathologies in the dependent frontal and maxillary sinuses could heal *without surgery* after the ethmoidal key areas had been cleared with usually very limited procedures. However, exact diagnostic identification of conditions in the lateral nasal wall, which underlie acute or chronic recurring sinusitis, is a prerequisite for FES. In so doing, the combination of diagnostic

nasal endoscopy with conventional or computed tomography (CT) has proven an ideal tool for this purpose.

Further development has refined the surgical technique, instruments and endoscopes used in FES as well as the radiological technologies employed.

Today, the improved diagnostic modalities allow for exact adaptation of surgery to the prevailing individual pathology but with a wide spectrum of indications. Although in the extreme a total sphenoethmoidectomy can be performed with this technique, its true advantage is that limited procedures are usually sufficient even in cases of massive disease. There is no need for routine partial or total resections of the middle turbinates nor considerable manipulations within the larger sinuses themselves. In the hands of an experienced surgeon, the technique has a minimal complication rate and there are few technique-related postoperative complaints, in contrast to those due to the more radical external approaches directed to the maxillary sinuses.

It is our current belief that the diagnostic and surgical possibilities of the Messerklinger technique (MT) of FES leave little indication for a more radical endonasal or even external approach to a chronic or recurring acute sinusitis as the first step of a procedure. As such, we rarely see any need for surgery directed to the frontal and/or maxillary sinus (including fenestration via the inferior nasal meatus).

Like all surgical techniques, the FES concept has its limits, contraindications and problems and also bears the well-known risks of endonasal ethmoid surgery. It therefore requires adequate training and experience.

## Pathophysiology of sinusitis

The mucus produced in the maxillary sinus is transported by the ciliary beat from the floor of the sinus in star-like routes along the walls of the sinus to the natural ostium. Its further active transport is through the narrow and complicated cleft of the so-called ethmoidal infundibulum (Fig. 1). This latter site is a sagittal pocket-like cleft in the lateral nasal wall, which is open posterior-superiorly towards medially. Its medial wall is basically formed by the uncinate process and the lateral wall by the lamina papyracea of the orbit. It opens through the hiatus semilunaris between the free posterior margin of the uncinate process (anteriorly) and the anterior face of the ethmoidal bulla (posteriorly) into the middle nasal meatus. The maxillary sinus ostium usually opens into the floor of the posterior third of the ethmoidal infundibulum and thus cannot be seen from the middle meatus. Depending on the deflection of the uncinate process superiorly, the ethmoidal infundibulum can pass on directly into the frontal recess above. If the uncinate process attaches to the lamina papyracea superiorly, the infundibulum ends in a superior blind, the so-called recessus terminalis. In such a case the frontal recess drains medially to the ethmoidal infundibulum (Fig. 2).

After the mucus from the frontal sinus has reached the frontal ostium, it has to pass through the frontal recess. It then passes either through the ethmoidal infundibulum or medial to this into the middle meatus. Whirl formation in the ciliary pattern may cause the mucus that has already left the frontal sinus to recircle and be transported back again into the frontal sinus [13, 14, 30, 31] (Fig. 3).

The frontal and maxillary sinuses communicate with the nose via a complicated system of very narrow clefts which provide their drainage and their ventilation. These prechambers – the frontal recess in the case of the frontal sinus and the ethmoidal infundibulum in the case of the maxillary sinus – are parts of the anterior ethmoid system and can be seen as ethmoidal "prechambers" of the larger sinuses. As long as these clefts are intact, they have a key position in providing physiological conditions for the dependent larger sinuses. These clefts are only a few millimeters wide and contain mucosal areas with ciliated respiratory epithelium that face each other. The ciliary beat thus can work on thickened or otherwise pathologically changed mucus *from both sides* and thus be more efficient. In an ostium, the ciliary beat can be effective even circularly.

If, however, in these narrow areas extensive contact of opposing mucosal surfaces occurs – whatever the cause for this may be – the ciliary activity can be impeded so that the spaces are completely blocked. The secretion in between such contact areas cannot be transported away anymore, except around these areas. As shown in Fig. 4, Messerklinger was able to demonstrate that infectious foci here can be established that clinically may be without symptoms for a long time. Under special conditions, however, infections can start here and spread to adjacent sites, especially to the dependent larger sinuses. The larger sinuses will be affected more quickly, especially if the infecting process occurs in one of the key areas mentioned above. Thus, even relatively limited disease in the ethmoidal infundibulum or the frontal recess may severely affect the respective sinus. Depending on the individual pathoanatomical situation, ventilation and secretion transport can be completely blocked. This can result in the retention of secretions, poor ventilation of the affected sinus and inflammation if superinfection occurs. The symptoms from this diseased sinus may very soon dominate the clinical picture. The *underlying* cause for the disease, however, in only a few exceptions will be found in the affected larger sinus itself.

The locations of preference for the contact areas in the nose include the frontal recess and the ethmoidal infundibulum, the cleft between the uncinate process and the middle turbinate, between the ethmoidal bulla and the middle turbinate (in the so-called turbinate sinus) or in the so-called lateral sinus above and behind the ethmoidal bulla (Fig. 5). Many anatomical variants of the lateral nasal wall and the middle turbinate help to narrow these stenotic clefts even more, thus apparently predisposing patients to recurring disease, especially if combinations of the variations exist. Here, disease starting in one of the clefts can trigger a cascade effect. The hiatus semilunaris may be affected from an infected area between the uncinate process and the middle turbinate. This in turn may lead to inflammation of the infundibulum and/or the frontal recess, from where the maxillary or the frontal sinus may be affected.

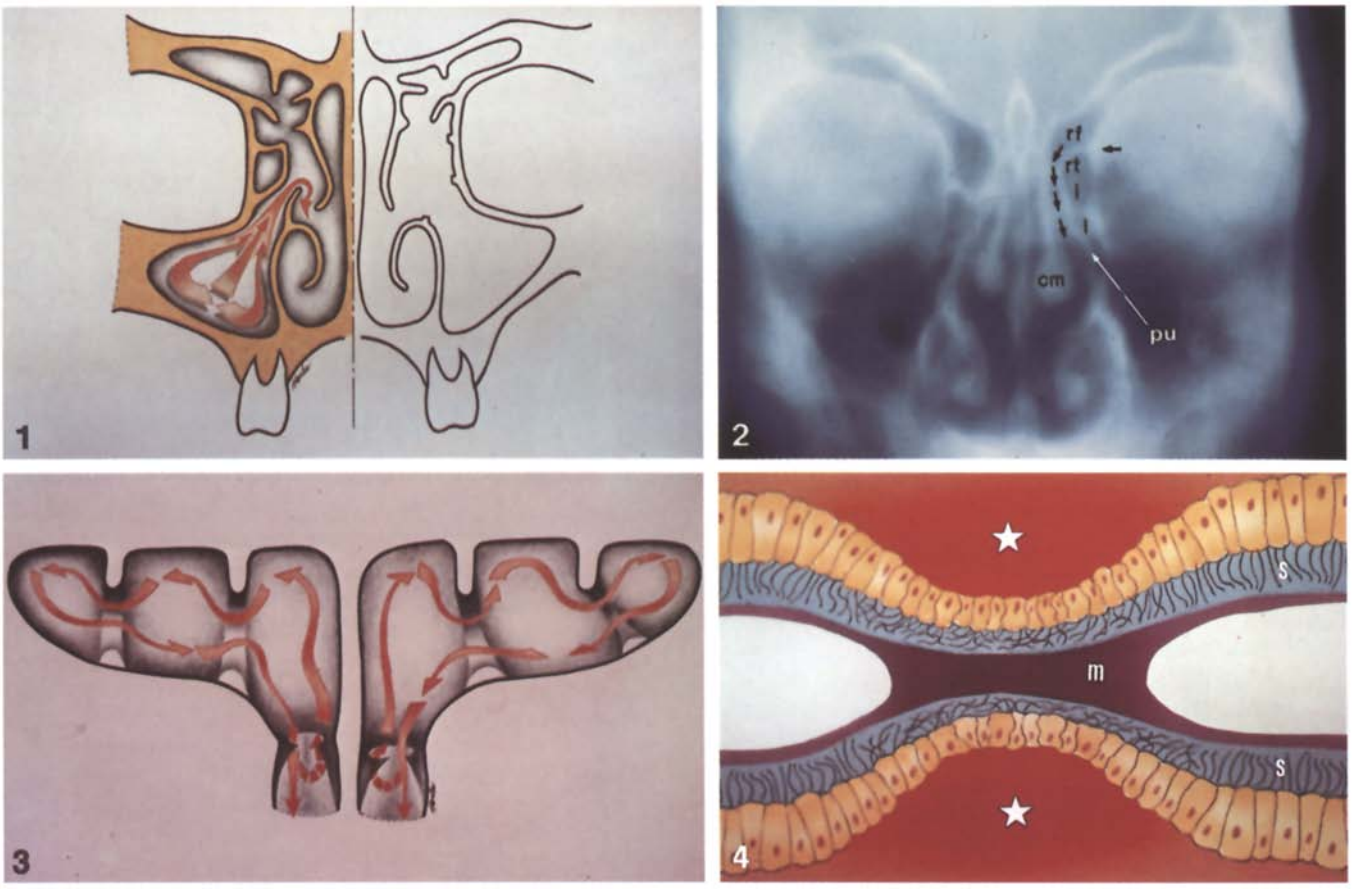



**Fig. 1.** Schematic drawing of secretion transport from a right maxillary sinus. The mucus is transported from the floor of the sinus along the wall towards the natural ostium, from there passing through the ethmoidal infundibulum and entering the middle meatus through the hiatus semilunaris before being transported back to the nasopharynx

**Fig. 2.** Conventional tomographic cut in the coronal plane through the anteriormost part of the ethmoidal infundibulum *(i)*. The uncinate process *(pu)* superiorly bends laterally and attaches to the orbit *(arrow)*. Thus, the ethmoidal infundibulum superiorly ends in a blind "recessus terminalis" *(rt)*. In this case, the frontal recess *(rf)* drains medially *(curved arrow)* to the ethmoidal infundibulum, which is located between the uncinate process and the middle turbinate *(cm)*

**Fig. 3.** Schematic drawing of secretion transport from the frontal sinus: mucus is transported along the interfrontal septum *into* the frontal sinus and then along the walls of the sinus to reach the frontal sinus ostium at its lateral aspect. Due to whirl formation in the ciliary pattern, mucus may recircle in the frontal recess and again get into contact with the inwardly directed secretion transport, thus once more entering the frontal sinus

**Fig. 4.** Schematic drawing of intensive mucosal contact area: due to massively swollen mucosa *(asterisks)* the ciliary beat is not effective any more and the mucus in between the contact areas cannot be transported away. *m,* (gel-phase of the) mucus; *S* sol-phase of the mucus, in which the cilia beat

However, in far-advanced disease it is often not possible to identify the point of primary origin of the disease, so that there are conditions in which the entire mucosal layer must be regarded as diseased, as in diffuse polypoid rhino-sinopathy.

Histological investigations of diseased mucosa of the ethmoidal clefts have been discussed in previous papers [28]. Several of these almost stereotypical features may add to a persistent cycle: the mucus produced becomes thicker and more viscous. There is the retention of secretions and cystic degeneration of the mucosal glands. The extravasation of secretions into the tissue may occur, giving rise to granulomatous reactions. Goblet cell metaplasia may lead to even more viscous secretions and create large mucosal areas without an active ciliary beat. If the resulting mucosal thickening happens to occur in one of the narrow key areas, this may lead to a more or less pronounced and lasting obstruction. If this condition does not resolve and/or cannot be cleared by medical treatment, infections may occur, spreading from the site of involvement to adjacent structures and then to the larger sinuses. More than 90% of the main airflow is directed towards the front of the middle turbinate, thus depositing particles and pathogens on the mucosa of the entrance to the middle meatus and the lateral nasal wall.

Figure 6 clearly demonstrates that not only massive disease of the anterior ethmoid (right side of the patient) may lead to maxillary sinusitis. A small circumscript lesion can trigger the same result (as reflected by recurring maxillary empyema in this case), if it happens to occur in one of the key areas such as the infundibulum, blocking the maxillary sinus ostium.

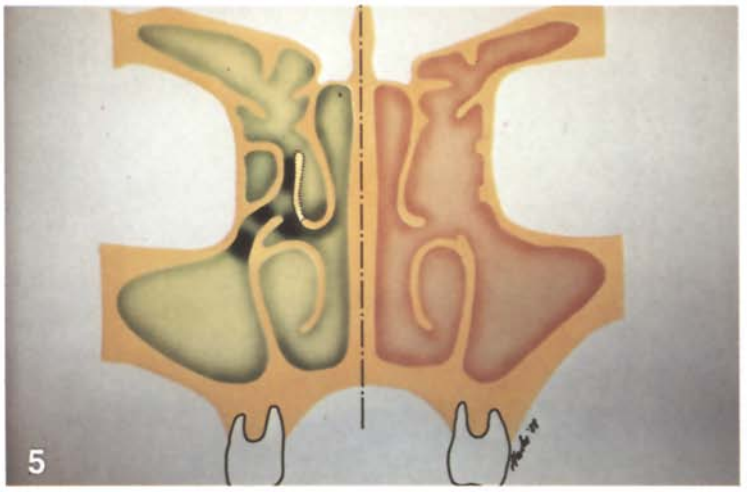




**Fig. 5.** Schematic drawing of critical narrow clefts in the anterior ethmoid. For a detailed explanation see text. On the right side of the picture, the artist's view shows the condition of the ethmoid after surgical clearing of the diseased areas

**Fig. 6.** CT scan of a patient with recurring "maxillary" sinusitis. The ethmoid disease on the right side of the patient is clearly demonstrated, blocking the infundibulum. There is considerable mucoperiostial thickening in the right maxillary sinus. On the left side, there is an empyema (endoscopic finding) in the maxillary sinus. The ethmoid shows only a very limited and circumscript mucosal thickening, but which blocks the ethmoidal infundibulum and maxillary sinus ostium. The left septal spur possibly added to the patient's symptoms

Messerklinger developed and published the first comprehensive and systematic method for endoscopic diagnosis of the lateral nasal wall [15–21, 24]. The rigid cold light endoscope in combination with conventional and/or computed tomography have proved to be ideal diagnostic tools. Both anterior and posterior rhinoscopy with general sinus X-rays are insufficient to provide adequate information about the areas the endoscopic surgeon is most interested with. As most anatomical structures of concern can be found in the frontal plane (i.e., the ethmoidal infundibulum, the frontal recess, the hiatus semilunaris, the ground lamella of the middle turbinate, etc.) and thus are approached by the endoscopic surgeon, conventional and computed tomography always should be performed in the direct coronal plane. Details of the radiological technique and the recommended parameters have been published by Zinreich et al. [40] and more recently by Kopp et al. [12]. Correct centering and windowing are of utmost importance for depicting the delicate bony and mucosal structures of the anterior ethmoid (Table 1).

**Table 1.** Data for direct coronal CT (adapted from Zinreich et al. [40])

| |
|---|
| Patient prone, head hyperextended |
| Gantry angulation: perpendicular to IOM-line |
| Sclice thickness: 4 mm |
| Table incrementation: 3 mm |
| Window: 1500–2200 HU |
| Center: *minus* 150 HU |
| Scan time: 5–7 s; zoom: 5 |
| Siemens DR3, Version E Software |

## Endoscopic diagnosis

The technique and findings of endoscopic diagnosis of the lateral nasal wall have been described extensively by Messerklinger [16, 20, 23] and other authors [10, 27]. Table 2 lists the most important anatomical variants that are now known to predispose patients to recurring sinusitis. Figures 7–9 demonstrate some typical endoscopic and corresponding radiological findings.

Zinreich et al. [40] in 1987 studied 100 consecutive patients with chronic sinusitis and evaluated the incidence of disease in the different paranasal sinus compartments as seen on CT. As shown in Table 3, the anterior ethmoids were affected most frequently. Apart from patients who presented with isolated cysts in the frontal or maxillary sinuses, all other patients with fron-

**Table 2.** Frequent anatomical variations predisposing to acute and recurrent sinusitis

| | |
|---|---|
| Septal deviation/spurs | |
| Agger nasi cells: | large, narrowing frontal recess |
| Uncinate process: | medially bent, laterally bent, curved anteriorly ("doubled middle turbinate"), fractures (trauma, iatrogenic), contacting turbinate, pneumatized |
| Middle turbinate: | concha bullosa, paradoxically bent, framing lateral nasal wall |
| Ethmoidal bulla: | large, filling turbinate sinus, contact areas, anterior growth, overlapping hiatus semilunaris, protruding out of middle meatus |
| Haller's cells: | Narrowing maxillary ostium |
| Combinations of all of the above | |

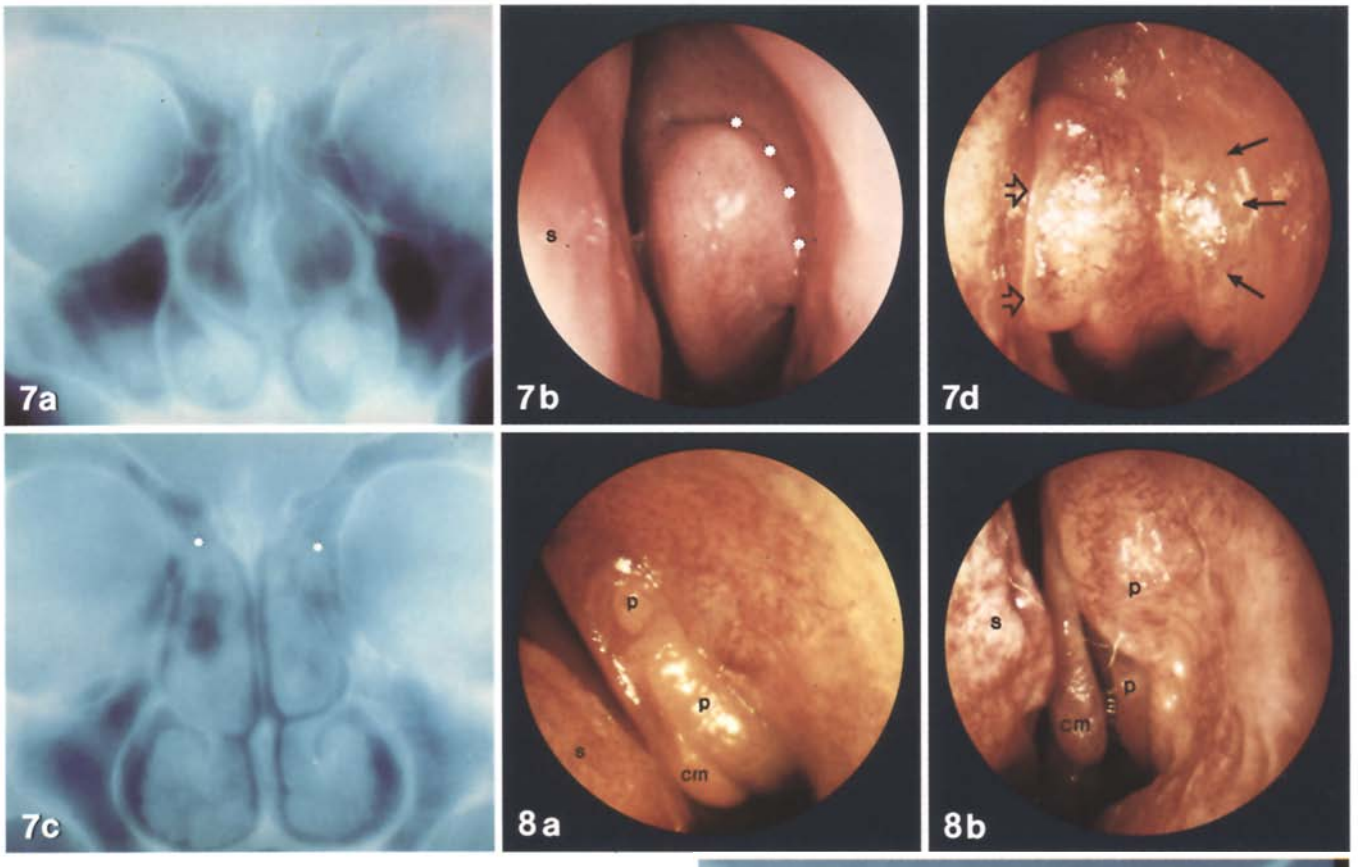




**Fig. 7.a** Huge concha bullosa of the middle turbinate on both sides that completely block the middle and common nasal meatus. **b** Endoscopic view of the left middle meatus of the same patient: large head of a concha bullosa bulges into the lateral nasal wall, blocking the entrance into the middle meatus. Extensive contact with the uncinate process *(asterisks)* is evident. *s,* Septum. **c** Concha bullosa of both middle turbinates with polypoid mucosal disease inside the turbinate cells. There is some opacification in the frontal recess as well *(asterisks)*. Note the reactive swelling and hypertrophy of both inferior turbinates, which normalized without requiring surgical correction after surgery of the concha bullosas. **d** Endoscopic view of a left side concha bullosa: polyps protrude from the contact area between the concha bullosa and the uncinate process *(arrows)* and the septum *(double arrow)*. *s,* Septum; *cm,* concha media

**Fig. 8a, b.** Endoscopic view of a diseased left anterior ethmoid: polypoid mucosa protrudes out of the middle meatus between the uncinate and the middle turbinate. *s*, Septum; *cm*, concha media; *p*, polyps. **c** CT scan of typical anterior ethmoid disease with maxillary sinusitis. After limited ethmoid surgery, the maxillary sinus healed without requiring any surgery

**Table 3.** CT distribution of paranasal sinus disease in 100 consecutive patients with chronic sinusitis [40]

| Involved sinus | % of patients |
|---|---|
| Anterior ethmoid | 72 |
| Maxillary | 65 |
| Frontal | 34 |
| Posterior ethmoid | 40 |
| Sphenoid | 20 |
| None | 7 |

tal or maxillary sinus disease presented with disease of the ethmoidal infundibulum or the frontal recess as well.

When evaluating CT scans and conventional tomographs it is important to not only look for mucosal thickening, soft tissue masses or for opacifications inside the sinus air cells or spaces, but to recognize and identify contact areas or other stenoses in key positions even if they are not significantly diseased at the time the scan was performed.

In our experience, an example of the importance of the ethmoids was found in patients who underwent sinus fenestrations and/or Caldwell-Luc procedures for chronic sinusitis and then continued to suffer from their previous symptoms. In a study that included more than 200

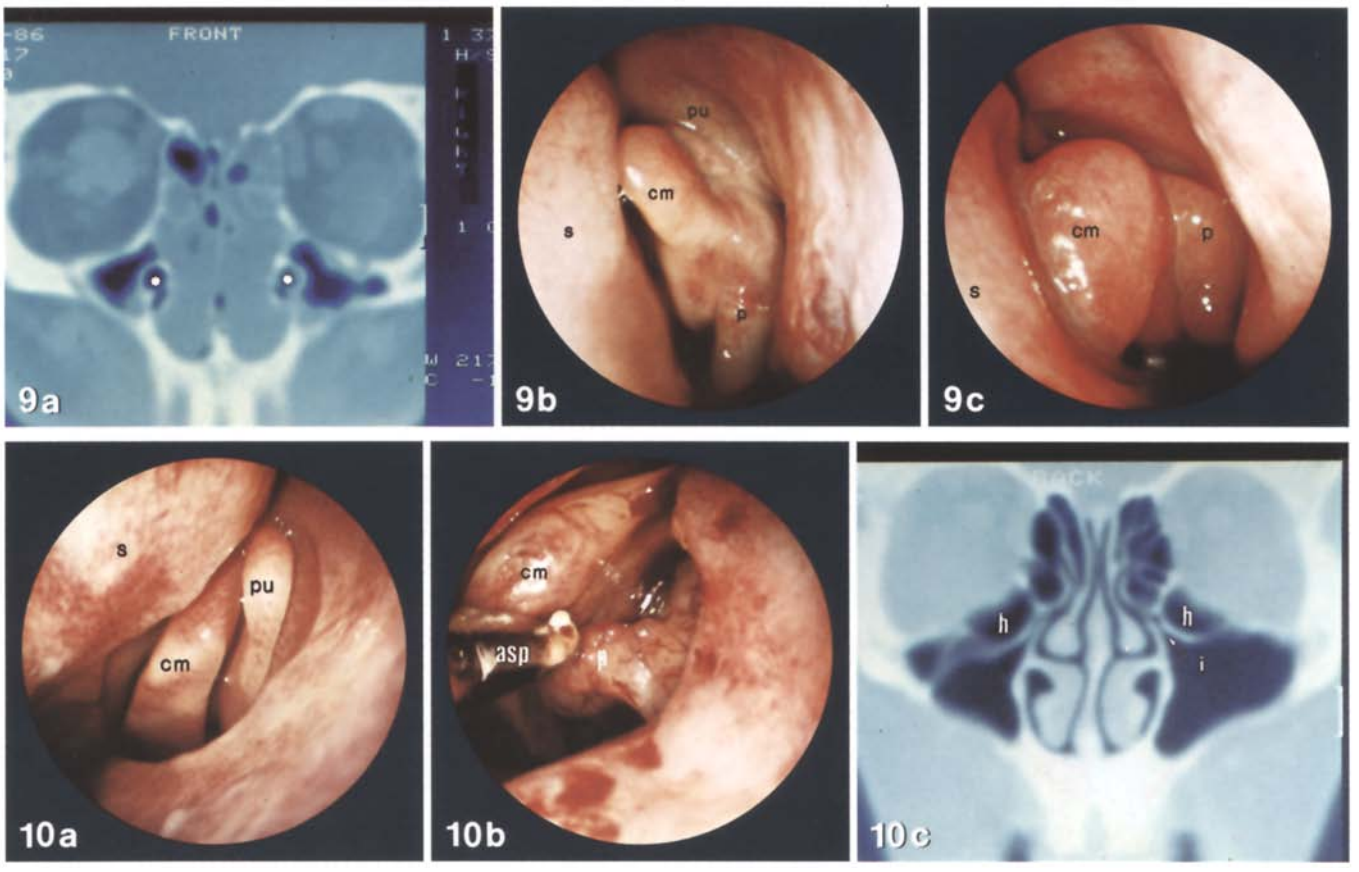



**Fig. 9. a** CT scan of patient with massive nasal polyposis and recurring maxillary sinusitis. There is only minimal swelling of the mucosal lining of the maxillary sinuses at the moment, but disease in the ethmoids is clearly present. *Asterisks* indicate nasolacrimal duct. **b, c** View into the left middle meatus in cases of polyposis. **b** A more isolated polyp protrudes from the contact area between the uncinate process and the middle turbinate. More polyps originated from the sinus of the turbinate and the anterior face of the ethmoidal bulla. **c** More pronounced nasal polyposis: the mucosa of the head of the middle turbinate shows polypoid change and there are polyps protruding from the middle meatus. *s*, Septum; *cm*, concha media; *pu*, uncinate process, *p*, polyps

**Fig. 10. a** Endoscopic view of the left middle meatus of a patient with recurring maxillary and frontal sinusitis. The uncinate process bends medially and anteriorly to protrude out of the middle meatus, giving the impression of a "doubled middle turbinate" [7]. **b** Operative findings after resection of the uncinate process: massive polypoid disease of the infundibular mucosa becomes visible. After its resection, access was free to the maxillary sinus and the frontal recess. *s*, Septum; *cm*, concha media; *pu*, uncinate process; *p*, polyps; *asp*, aspirator. **c** CT scan of an anatomical variant in an asymptomatic patient showing bilateral Haller's cell growing into the orbital floors, thus narrowing each ethmoidal infundibulum and the maxillary sinus ostium from above and behind. *i*, Infundibulum; *h*, Haller's cell

such patients, we were able to demonstrate that in most of these cases disease of the ethmoid compartments was the cause for the persisting problems. The patients' complaints did not correlate with whether or not a window was present in the inferior meatus or with the degree of pathology inside the maxillary sinus, if such was present. However, the patients' problems correlated very well with diseases identified in the lateral nasal wall. The overall extent of the disease was not significant in these cases, but its localization (Fig. 11) [11, 33].

## Surgical technique

### *Surgical indications*

The most frequent indications for FES are listed in Table 4. Since it is not necessary for a sinusitis to present with the classical triad of symptoms (i.e., abnormal secretions, nasal obstruction and headaches), the importance of an exact endoscopic diagnosis must again be stressed. Sometimes only one of the classic symptoms is present or the symptoms can be such that they seem not to be sinus-related at all. A "normal" standard X-ray of the sinuses *absolutely does not* rule out a sinogenic origin of the problems.

By far the majority of our patients are operated on because of more or less massive polyposis. If indicated, in these cases maxillary sinoscopy (which is not a routine part of our surgical procedure of FES) is performed, preferably via the canine fossa.

### *Technique*

The single steps of the FES have been described by us and others in several publications [8, 25–30, 32, 33] and therefore are outlined only briefly again. The general aim of surgery is to clear diseased ethmoid clefts and compartments under guidance of the rigid endoscope and to reestablish ventilation and drainage of the diseased larger sinus via their physiological routes. The frontal and maxillary sinuses per se rarely require more extensive manipulations. If

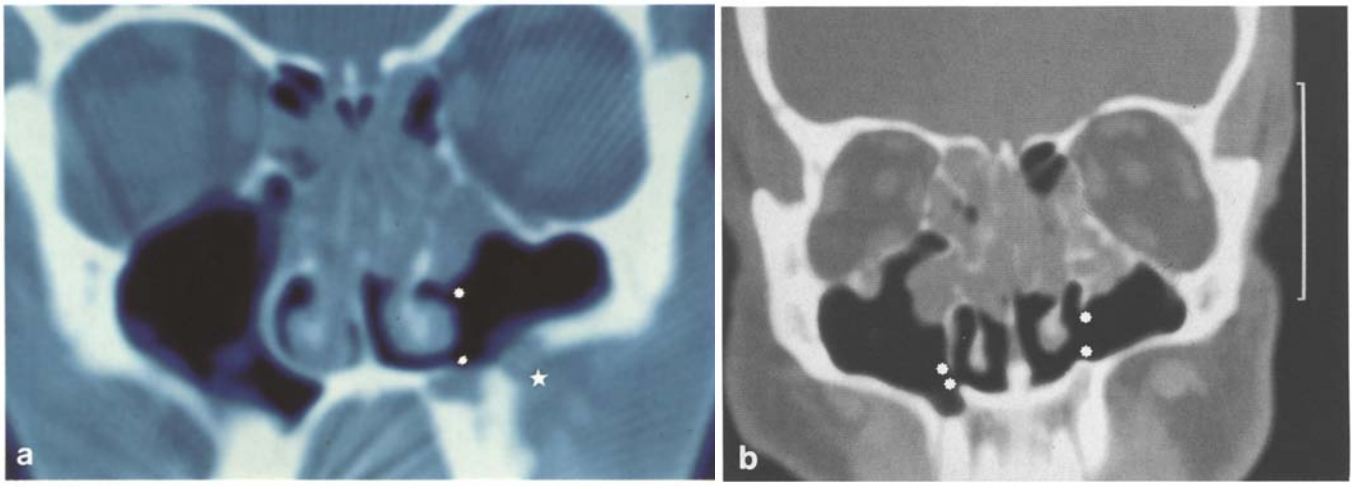



**Fig. 11a, b.** CT scans of patients after Caldwell-Luc (**a**) and fenestration operations (**b**) The remaining ethmoid disease is clearly demonstrated, explaining the patient's persisting clinical problems despite patent windows into the inferior meatus (*asterisks*). The *large asterisks* indicate bony defect in facial wall of maxillary sinus after Caldwell – Luc surgery (**b** by courtesy of S. J. Zinreich, MD, Baltimore)

necessary, the maxillary sinus ostium is enlarged at the expense of the anterior and/or posterior nasal fontanelle, resulting in a window in its physiologic place in the middle nasal meatus. In our experience there is no need for inferior meatal fenestration. If the frontal sinus is diseased, clearing the frontal recess in most cases of inflammatory processes will also produce healing of the sinus without the need for additionally enlarging the sinus ostium itself.

Except for children, the surgical procedure is performed with the patient under sedation with topical and local anesthesia. This provides an excellent view of the area to be operated on and allows for careful and atraumatic handling of the instruments. It further helps to reduce any bleeding, so that no packing is usually required postoperatively.

Depending on the pathology present, our technique of FES allows a stepwise, individualized operation ranging from an isolated opening of the ethmoidal infundibulum to a total sphenoethmoidectomy, although the latter is done in rare cases only. Even then we have found that there is no need to partially or completely resect the middle turbinate. The true advantage of our procedure is that it is based on exact diagnosis, thus limiting any surgery required and avoiding "routine" total spheno- or ethmoidectomies. This goes along with decreased patient morbidity.

In the majority of our cases, the anterior ethmoid is entered by resection of the uncinate process, which opens the ethmoidal infundibulum. The entire surgical technique on several occasions has been incorrectly labelled "infundibulotomy according to Messerklinger." We want to point out that this is a misnomer. Messerklinger was not the first surgeon to resect the uncinate process (and thus perform an infundibulotomy), nor does the term "infundibulotomy" describe the entire technique. The "infundibulotomy" is nothing more than an incision to open the anterior ethmoid. The term also tells nothing about the diagnostic approach used and little about the surgical possibilities involved in the MT of FES [25].

For the various steps of the surgical procedure only a few special instruments are required. These are inserted through the nostril parallel to the endoscope's shaft and allow for precise manipulations. Easy-to-handle endocameras and articulated arms provide excellent teaching and demonstration modalities for residents and documentation. Working almost exclusively under local and topical anesthesia with the resulting good hemostasis, with no need for self-retaining specula, allows for atraumatic surgery with preservation of as much mucosa as possible.

**Table 4.** Spectrum of indications for FES

- Polypoid sinusitis (60%)
- Chronic and acute recurring infections of all sinuses
- Nasal obstruction
- Headaches
- Pressure feelings
- Postnasal discharge
- Epiphora
- Anosmia
- Mucoceles of all sinuses
- Retention cysts
- Orbital complications
- Sinus mycoses
- Persisting complaints after Caldwell-Luc operations or fenestrations
- Tubal dysfunctions
- Adjuvant surgery to allergy treatment
- Antrochoanal polyps
- Mucoviscidosis

In general, even if outpatient surgery is possible, we recommend that patients remain hospitalizied overnight for observation following surgery. Most of our patients have been hospitalized an average of 3 days (1–12 days), with sickness leave from work averaging 8 days (range 2–28 days).

Depending on the pathology present, the ethmoid cavity usually heals within 2–3 weeks after surgery; the dependent larger sinuses, especially in cases of diffuse polyposis, may take as long as 6 weeks until they normalize.

The usual postoperative care is restricted to removing crusts and excess wound secretions from the operative cavity. This is best done under endoscopic control.Cortisone-containing ointments or drops are also used in special cases. Care must be taken to prevent adhesion and scar formation between the middle turbinate and the lateral nasal wall [8, 11, 27, 31].

## Allergy and MT

In general, allergic disease of the upper airways is not a primary indication for surgery. If the nasal symptoms of

an allergic patient do not respond properly to hyposensitization or other anti-allergic therapy, however, and additional anatomical variants promoting obstruction – like a large concha bullosa or an ethmoidal bulla – can be identified by diagnostic endoscopy, a limited surgical procedure may help considerably. In these cases, the MT should be seen as an adjuvant therapy, which of course cannot heal the allergy but may help to improve the patient's symptoms in addition to further anti-allergic treatment.

## Septal deviations and MT

Large deviations of the entire nasal septum as well as circumscribed abnormalities can cause nasal obstruction and be the underlying cause of paranasal sinus diseases. These are especially prone to occur when the middle turbinate is pushed laterally, narrowing the entrance into the middle meatus. Spurs and crests can impact against the turbinates and/or other areas of the lateral nasal wall and present clinically as additional factors disturbing function or (for example) causing headaches.

Clinical experience has shown that many patients with even very pronounced deviations, crests or spurs may have little or no problems at all, or have symptoms due to infections of the other, "wider" side of the nose. We therefore are very restrictive with indications for septoplasties except in extreme cases or when there is an undisputed connection to clinical symptoms. We have also found that most of our patients will resolve their symptoms after an ethmoidal focus of disease is cleared *without* requiring correction of the sometimes considerable septal deviations [32].

The criteria we apply are the following: if a 4-mm telescope plus the required instrument can pass the stenosis caused by the septal deviation, we will always treat the ethmoid problem first. Only if the ethmoid cannot be reached due to the stenosis will we perform a septoplasty first. If after a couple of weeks ethmoid disease persists, we then correct the septum in a second stage. Only in cases of massive polyposis combined with extreme septal deviations do we perform a one-stage procedure. Circumscribed septal spurs – if connected with clinical symptoms – can easily be resected during the endoscopic procedure without the need for a complete septoplasty. The need for the latter has sharply decreased in our patient population since our use of endoscopic diagnosis and the MT.

## Limitations and contraindications to FES

Bony obstructions of the frontal sinus ostium or stenoses caused by large bony changes or scarrings should not be approached with the technique of FES. If the area of the frontal recess or the frontal sinus ostium cannot be localized exactly, as for example after a previous radical sinus operation with resection of the middle turbinate, there is still the possibility of a combined approach being used. Through a trephine in the anterior sinus wall a 30° or 70° endoscope can be inserted into the sinus to allow visual control of the endonasal approach via the frontal recess. In these cases of ostial stenosis or obstruction, a polyethylene drain is inserted and left in place for 3–6 months. Procedures like these usually require general anesthesia.

If in an acute sinusitis with orbital complications only minimal or discrete signs of meningitis or any other intracranial complication are present or if there is an osteitis or osteomyelitis of the frontal bone, we regard these as contraindications for a primary endoscopic approach. Similarly, although mucoceles are usually an ideal indication for FES, the occurrence of such processes far laterally in the frontal sinus may result in their not being reached endonasally via the sinus ostium. The same is true for symptomatic cysts or isolated polyps in the periphery of the frontal sinus.

We have used the technique of FES for smaller benign tumors, circumscript inverting papillomas, closure of CSF leaks and the removal of foreign bodies out of all sinuses. The technique is also helpful for decompressing the orbit in cases of endocrine ophthalmopathy or for performing a dacryocystorhinostomy under endoscopic guidance. We do, however, not consider invasive on malignant disease an indication for endoscopic surgery.

## Results

Due to the wide spectrum of different indications, no overall success rate can be given for our cases, as this varies with the indications.

During 1986 and 1987 we examined more than 500 patients who had been operated on between 8 months and 10 years previously. All patients underwent diagnostic nasal endoscopy as an outpatient procedure. The case history of each patient as well as a detailed questionnaire was evaluated by a third party.

Table 5 lists the various surgical procedures that the 500 patients underwent unsuccessfully prior to their endoscopic surgery. There is an impressively high number of patients who experienced no relief from sinus fenestrations of Caldwell-Luc procedures and septoplasties. More than 10% had one or even repeated septoplasties performed. We could not determine the percentage of patients in whom turbinates were trimmed or posterior turbinate ends were resected, as many patients were not able to recall whether or not such manipulations were performed. We have generally found that regardless of the extent and the degree of the disease, our best results were achieved when anatomical variants could be identified as the underlying causes of the patient's problem.

**Table 5.** Preceding therapies (500 patients)

- Repeated maxillary irrigations
- 82 fenestrations and/or radical operations (some multiple and bilateral)
- 54 septoplasties
- 69 patients with multiple previous polypectomies

**Table 6.** Best results from FES

- Anatomical variants causing stenoses
- Cephalgia
- Mycoses
- First procedure
- Allergy: *if* good response to medical treatment

**Table 7.** Postoperative onset of relief following FES

| | |
|---|---|
| • Cephalgia/pain: | at once |
| • Fullness, pressure felling: | at once |
| • Epiphora: | at once |
| • Congestion: | days to 6 weeks |
| • Crusts, secretion: | days to 6 weeks |

Among the cases reviewed very good results were achieved in patients with sinogenic headaches. Of the patients in whom headache was the only or leading symptom, 88% reported that their problem had completely disappeared or had become considerably better [32]. Very good results were also achieved in cases of paranasal sinus mycoses, all of our cases being non-invasive aspergillus mycoses [26] (Table 6).

There was no statistically significant influence of allergy on our surgical results. As mentioned previously a clearly allergic rhinosinusitis is not a primary indication for endoscopic surgical treatment. If, however, the endoscopic procedure is used as an adjuvant therapy to treat aditional stenosis in the middle meatus/ethmoid complex, the effects of such surgery were clearly better in patients who had already shown some improvement to previous anti-allergic therapy.

In general, our results were more favorable if the endoscopic surgery was a patient's first surgical procedure. Patients unanimously reported that such symptoms as headaches, pressure and the feeling of fullness between the eyes or epiphora usually were gone immediately (i.e., a few hours) after FES. Even postnasal drip, which was one of the symptoms disliked most by the patients, usually stopped within the first few days after surgery, as did the feeling of nasal obstruction (Table 7).

Our worst results have been found in a clinical entity that we call "diffuse polypoid rhino-sinopathy." This does not refer to the overall volume of the nasal polyps present but to their clinical appearance. Affected patients usually present with a diffuse polypoid swelling of the entire nasal and paranasal sinus mucosa. Hyperplastic mucosa from the anterior portion of the middle turbinate frequently cannot be differentiated from mucosa protruding out of the middle or even superior nasal meatus. In these cases, only rarely were we able to trace polyps back to a more or less well-defined and circumscript origin. These patients typically do not have any allergies, but aspirin intolerance is a more common finding, frequently associated with asthma.

Overall 246 of the 500 patients suffered from more or less massive nasal polyposis. Sixty-four of these patients had a clinical picture of diffuse polypoid rhino-sinopathy, with up to 18% having recurrences and some having multiple recurrences. As a rule, these latter patients presented with nasal obstruction and recurrent polypoid mucosal swelling within a relatively short time after surgery (usually within a few weeks). These were the only patients whom we treated systemically with corticosteroids but with extremely variable and unpredictable results. Repeated surgical procedures in a few cases resulted in a surprisingly long-lasting improvement of the condition, although the second or third surgical approach was no more radical than the first one. In these cases partial or total resections of the turbinates, external approaches to maxillary sinuses, total sphenoethmoidectomies etc. had no better results in our hands than did the more conservative endoscopic approach. In contrast, the patients clearly suffered more from postoperative complaints after the radical procedures, which in these cases also seemed not to offer a valid solution for clearing disease [1, 3, 36, 37]. It is our impression that diffuse polypoid disease is a general mucosal disease, whose cause(s) is/are not completely understood for the time being. The treatment of this condition apparently requires more than an isolated surgical approach, regardless of the technique used.

Our second unsolved problem has involved patients whose sinus mucosa looks macroscopically normal and whose complaints postoperatively are clearly less. However, these patients still produce a glue-like highly viscous secretion that apparently cannot be transported out of the sinuses by the mucociliary activity. This condition can be found especially in asthmatic patients or patients with a sinobronchial syndrome. Apparently, it is the result of a glandular dyscrinism, the reason for which is still unclear. In these cases, usually no basic pathological findings can be detected. Symptomatic therapies frequently are as frustrating as attempts with locally or systemically applied mucolytic agents. Sometimes the secretions present are so viscous that they cannot be aspirated and removed even with strong suction. Here too, more radical surgical approaches have been insufficient for producing better results. In selected cases we have performed a fenestration in the inferior meatus to allow for the secretions to flow following gravity or at least give us better access for placing an aspirator in the maxillary sinus.

The most unfavorable conditions for an endoscopic procedure to succeed have proven to be combinations of diffuse polypoid sinusitis with multiple allergies resistant to anti-allergic therapy, preceding operations that have resulted in the loss of anatomical landmarks, intensive scarring and cases with longstanding bronchial asthma and glandular dyscrinism with highly viscous secretions.

When using the endoscope for follow-up of our patients – even with our ability to look into the far corners of the sinus system – we realized how difficult an objective evaluation of our success rate could be. We came across patients who were completely free of symptoms following surgery, some for many years, but with abnormal mucosa seen endoscopically. We encountered slight inflammatory changes, some polypoid thickenings and crusting or prominent secretions. On the other hand,

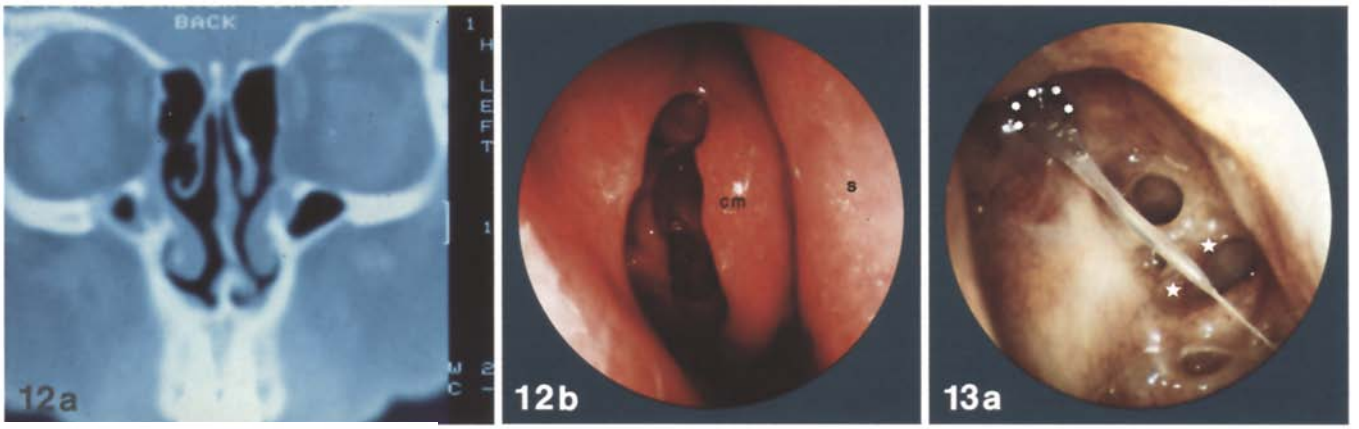




**Fig. 12. a** CT scan of normalized ethmoid area after functional endoscopic surgery. **b** Endoscopic view of the middle meatus after endoscopic surgery (for diseased concha bullosa and anterior ethmoid.) The mucosa has normalized without the entire ethmoid having been exenterated. The medial lamella of the concha bulla was not sacrificed to provide a normal middle turbinate

**Fig. 13. a** View into a right middle meatus 8 weeks after endoscopic surgery for massive ethmoid disease. The mucosa appears to be normal, but there are still some highly viscous non-purulent secretions from the frontal sinus ostium (*asterisks*). When the mucus was aspirated, the frontal sinus ostium appeared to be completely normal and the mucosa within the sinus showed no signs of inflammation either. *Asterisks* indicate anterior ethmoidal artery. **b** Left middle meatus. Extensive scars between the head of the middle turbinate and the lateral nasal wall following endoscopic surgery. *s*, Septum; *cm*, concha media

some patients whose mucosa endoscopically looked completely normal and whose sinus ostia all were free still complained of some remaining problems, for which no objective cause could be identified (Fig. 12).

The numbers shown in Table 8a and b should therefore be interpreted as very subjective evaluations of our patients. In our questionnaire the patients were asked not only to consider the degree of their improvements but the duration as well. As shown in Table 8, 85% of all patients (425/500) reported good or very good results from their treatment, 6% (30/500) reported satisfactory results, 4.2% (21/500) moderate success only and 4.6% (23/500) no improvement at all.

However, no patient in the last group complained about aggravation of symptoms postoperatively. One patient had an initial attack of asthma in the year after the surgery, although it was not clear whether or not there was a causal connection with the surgery.

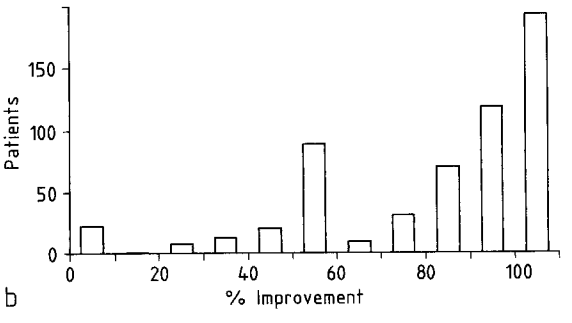
We are currently conducting a special investigation concerning patients with bronchial asthma. In this paper we only want to note that 70% of all of our patients with bronchial asthma reported a sometimes impressive or in many cases longstanding improvement of their complaints. Twenty percent showed only a transient improvement and 10% reported no improvement at all. To date, we have found that the preoperative duration of the asthma was not a negative factor unless there were multiple allergies involved.

Even if it is clinically evident that the surgical treatment of sinus disease in cases of bronchial asthma or sinobronchial syndrome has a benefical influence in the majority of cases, we still lack any criteria to *predict* in which patients surgery will bring improvement or how long any improvement will last. Our positive experience so far has encouraged us not only to operate in cases of massive disease but even when there are relatively circumscript endoscopic changes. There also is some evi-

**Table 8a, b.** Improvement of symptoms: patients' evaluation ($n = 500$)

| | | |
|---|---|---|
| 85%: | Very good/good | (425 patients) |
| 6%: | Fair | (30 patients) |
| 4.2%: | Moderate | (21 patients) |
| 4.6%: | No improvement/bad | (23 patients) |

Follow-up time: 8 months–10 years



dence that neurotransmitters liberated in areas of diseased and/or contacting nasal mucosa may act as trigger factors for this disease [32, 35, 38], further justifying surgical correction of these sites.

## Complications

In about 8% of all patients followed, varying degrees of synechiae were found mainly between the anterior portion of the middle turbinate and the lateral nasal wall. This is especially prone to occur if opposing wound areas have been created during surgery (Fig. 12). A further factor predisposing to synechia is a very narrow entrance into the middle meatus, as for example due to a paradoxically bent middle turbinate or a very massive turbinate head bulging into the lateral nasal wall.

Not all synechiae must necessarily mean that recurrent clinical problems will be back. Only 15% of the patients in whom synechiae were identified suffered from recurring or persisting problems. Problems usually arose when synechia led to stenosis of the middle meatus or blocked the ethmoidal recesses where secretions were retained and ostia narrowed or scarred. In several cases the mechanical blockage at the entrance of the middle meatus was apparently enough to give patients the feeling of an obstructed nose despite the fact that the ethmoid behind the synechia and all other passages were completely normal. This again stresses the importance of direct ventilation of the middle nasal meatus for the subjective feeling of having "free" nasal airways.

Synechiae can easily be identified and treated endoscopically. They are divided and a Silastic or other kind of stent is fixed in place for several days. This usually will take care of the problem.

"Overlooked" diseased ethmoidal clefts and cells can be the reason for recurring or persisting problems. These cases usually result from either insufficient diagnoses or follow surgery. Bleeding or other conditions impeding vision and orientation are the most frequent reasons causing a surgeon to either overlook or not reach a diseased ethmoidal compartment. In most of these cases the cause for the persisting problem can usually be well identified and treated endoscopically.

The number of stenoses of an enlarged maxillary sinus ostium was surprisingly small in our experience. Only 8 patients, representing a little less than 2% of our group, had such stenoses. In one patient three consecutive stenoses occurred without any evident reason despite a proper surgical technique.

Reepithelization of the margin of the enlarged natural ostium apparently occurs very rapidly. One explanation for this may be that the transport of secretion from the maxillary sinus immediately aims for the natural ostium. In most cases a circular lesion of the ostium can be avoided by enlarging it at the expense of the anterior nasal fontanelle only, leaving the posterior circumference untouched. From our clinical experience we have found that a 3-mm diameter is the minimum patency for an ostium to function sufficiently. In independent studies, Kennedy et al. [11] have also demonstrated similar results concerning the rare tendency of stenosis to occur. These findings have shown that enlarging the natural ostium in its physiological location in the middle meatus can be regarded more effective and physiological than a fenestration in the inferior meatus. It is our feeling that Hilding's postulate [4] never to touch the virginity of the natural ostium is no longer valid.

Other complications encountered after FES in the 500 patients studied included the following. Nine patients had lesions of the lamina papyracea and the periorbita. Three of these patients presented with a lid emphysema, while two patients had minor hematomas in the inner canthus. None of these cases had persisting problems and none experienced diplopia.

Eleven patients had intra- or postoperative bleeding that required a packing of the nose, including one posterior packing. This was the only patient in whom blood transfusions were necessary due to his blood loss. However, we were unable to identify a bleeding disorder preoperatively in this case.

In 10 cases repeated surgical procedures were performed due to intraoperative bleeding obscuring the surgeon's vision endoscopically.

In a few patients with maxillary sinus mycoses, very painful, persistent granulomatous reactions and infiltrations of the soft tissue of the cheek followed instillations of antimycotic ointments into the maxillary sinus through the enlarged natural ostium. The ointment apparently reached the soft tissues of the cheek through the trocar perforation created during a preceding maxillary sinuscopy. We have since started to instill antimycotic ointments no sooner than the 6th postoperative day – after the trocar perforation has closed safely – and have not encountered this complication any more.

In one case a Merocel sponge that was placed between the middle turbinate and the lateral nasal wall to prevent adhesions was "forgotten." This sponge was removed several months later after causing considerable problems for the patient. Currently all Merocel sponges for intranasal use are tagged with a suture which is then taped to the patient's cheek. This serves as a reminder that the stent still needs to be removed.

Intraoperative *bleeding* is usually *not* a major problem when surgery is done under local and topical anesthesia. The bleeding source in most cases is not an isolated vessel but the result of non-specific sources from mucosal surfaces or margins. This can be extremely annoying if an operation is performed when acute infection and the resulting hyperemia are present. Repeated inlays of cotton wool swabs soaked in vasoconstrictors (adrenaline) should be sufficient to control bleeding in most cases [6], so that surgery can be continued after 2 or 3 min. When diffuse mucosal bleeding renders the surgery more difficult, a suction-forceps can be of great help (Fig. 14); bipolar cautery in our experience only proved to be of advantage in cases of bleeding from isolated vessels. In general our average blood loss was less than 30 ml per patient, with the exception of those patients requiring packing.

Bleeding from the anterior ethmoidal artery normally is not as troublesome as one might expect. The

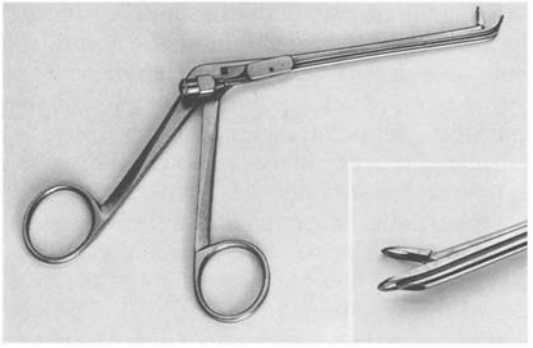


**Fig. 14.** Straight forward and upbiting suction forceps (Storz, Tuttlingen, FRG): a small suction channel has been integrated into the inferior branch of the forceps without rendering these too bulky. There is a Luer-lock for attaching suction. A finger control helps to regulate the intensity.

**Table 9.** Complications (500 patients)

| | |
|---|---|
| • Orbital Penetration: | 9 |
| – With lid emphysema: | 3 |
| – Persisting problems | 0 |
| • Bleeding (Packing required): | 11 |
| (Bellocq): | 1 |
| • Blood transfusion(s) required: | 1 |
| • Repeated procedures due to bleeding: | 10 |
| • Soft tissue infiltration after sinoscopy: | 5 |
| • "Forgotten" Merocel sponge: | 1 |

vessel in most cases can be clearly identified and a lesion thus avoided. However, a major complication can result if the artery is torn and the vessel retracts into the orbit where it continues to bleed. The resulting intra- or periorbital hematoma bears all the imminent dangers of orbital complications, including blindness. Within a few seconds a massive protrusion of the eyeball may occur, rendering the eye completely fixed and immobile. In such a case the surgeon must be prepared to decompress the orbit immediately. This complication stresses another advantage of surgery under local anesthesia: the fundus can be readily controlled and vision monitored if an orbital decompression is needed. Under general anesthesia, valuable time can be lost waiting for the patient to wake up for assessing visual fields [9, 34].

Another area where bleeding may occur is the vicinity of the posterior end of the middle turbinate. Due to the proximity of the sphenopalatine foramen and its vessels entering the nasal mucosa, lesions here can easily occur. Except in cases of a massively pneumatized concha bullosa, surgical manipulations of the middle turbinate are not a part of the MT.

Table 10 shows all of our serious complications in well above 4500 patients. In this group, we encounted three CSF leaks but no cases of meningitis. Two of the patients with CSF leaks suffered from recurrent nasal polyposis and had undergone multiple previous surgeries

**Table 10.** Severe complications since 1976 (over 4500 cases, 3 surgeons)

| | |
|---|---|
| • CSF leaks: | 3 |
| • Pneumatocephalus: | 1 |
| • Intraorbital bleeding: | 2 |
| • Meningitis: | 0 |
| • Partial loss of vision, | |
| Diplopia: | 0 |
| Blindness: | 0 |
| • Fatalities: | 0 |

elsewhere. Intranasal anatomy during FES was very unclear due to previous resections of landmarks (such as the insertion of the middle turbinate) and due to scarring and adhesions. In one patient, the CSF leak was clearly identified intraoperatively. Another patient only showed symptoms on her 3rd postoperative day when headaches started after she had blown her nose. A CSF leak was not recognized intraoperatively and the patient had had no postoperative problems until then. When the headaches got worse, a X-ray was performed and demonstrated a pneumocephalus.

In both of these cases the lesion occurred at the point of least resistance of the anterior ethmoid roof: medially, where the anterior ethmoidal artery leaves the ethmoid to pass into the olfactory fossa [6, 9, 39]. These cases were managed by an external approach using lyophilized dura and fibrin glue.

The third CSF leak occurred in a patient who years before had experienced a frontobasal fracture. There were no defects visible in a preoperative CT scan. Intraoperatively, a lesion was found 4–5 mm posterior to the anterior ethmoidal artery, possibly in an area of an old posttraumatic bony dehiscence. This case was immediately controlled endoscopically and the leak closed using lyophilized dura, a mucosal flap and fibrin glue. Subsequent healing was normal.

Intraorbital bleeding in two of the cases was due to lesions of the anterior ethmoidal artery. Fortunately, none of these cases required orbital decompression and medical therapy with ophthalmological and ultrasound control of the orbit prevented a lesion or compression of the optic nerve. After the hematoma had resolved no permanent problems occurred concerning ocular motility or vision.

No patient in our overall series had persisting ophthalmic complications and there was no case with impairment of visual fields, diplopia or blindness.

As in many of the cases where FES dated back more than 10 years, patients were not routinely asked about anosmia, nor were olfactory tests performed. As a consequence we cannot produce sound statistical data concerning this subject. However, 23% of the 500 patients seen in follow-up reported some (varying) degrees of anosmia preoperatively. In the majority of these cases the symptoms improved subjectively after surgery. However, in most of these cases exact (retrospective) quantification of the anosmia was not possible.

## Conclusions

The MT is a primarily *diagnostic* endoscopic concept, which is based on the understanding of the pathophysiology of sinusitis. Additionally, the combination of diagnostic endoscopy of the lateral nasal wall using rigid scopes with conventional or computed tomography in the coronal plane has proven to be the ideal tool for the investigation of inflammatory diseases of the paranasal sinuses. With this technique diseases and lesions can be identified and consequently treated that otherwise might have gone unrecognized.

With mostly very limited surgical procedures, functional endoscopic sinus surgery allows diseased ethmoidal compartments to be cleared, stenotic clefts enlarged and the prechambers to the frontal and maxillary sinuses freed from disease. By so doing, there is rarely a need to operate on the larger sinuses themselves, although a total sphenoethmoidectomy can be performed with this technique if necessary. The basic idea, however, is to *avoid* this as a routine procedure, since the surgery is based on exact diagnoses to allow a very individualized staging according to the prevailing pathology.

Rewards of a meticulous technique are a significantly decreased patient morbidity and less trauma, which allows surgery to be done even in patients for whom general anesthesia would present an additional risk.

The Messerklinger technique has its clear limits as well as its specific problems. Even though it may not be as effective in cases of diffuse polypoid rhino-sinopathy or mucoviscidosis, sometimes considerable improvement can be achieved in many of these cases. However, as more radical surgical techniques do not have any significantly better long-term results, the MT may be more preferable because of its less traumatic approach in these cases.

The technique of FES requires thorough training and a very good working knowledge of ethmoid anatomy with all its many possible variations, since it bears all of the risks and hazards of endonasal ethmoid surgery. Applied correctly when indicated, the technique has a minimal complication rate in the hands of an experienced surgeon [34].

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# *Announcements*

**8th International Course in Functional Corrective Nasal Surgery, 10–15 June 1990, Utrecht, The Netherlands**

For further information, please contact: Prof. Dr. E. H. Huizing, Department of Otorhinolaryngology, University Hospital, Utrecht, The Netherlands

**The Seventh Cambridge Course in Advanced Otolaryngology, 9–13 July 1990, Corpus Christi College, Cambridge, UK**

For further information, please contact: Mr. D. A. Moffat, ENT Department, Addenbrooke's Hospital, Hills Road, Cambridge, CB2 2QQ, UK

**7th Danube Symposium on Oto-Rhino-Laryngology, 30 August – 2 September 1990, Budapest, Hungary**

For further information, please contact: Congress Secretariat, Kongressbüro Motesz, Postfach 32, H-1361 Budapest, Hungary

**Genetics of Hearing Impairment Symposium, 24–26 September 1990, New York, USA**

For further information, please contact: Robert J. Ruben, M.D., Chairman, Department of Otolaryngology, Montefiore Medical Center, 111 East 210th Street, VCA 4, Bronx, NY 10467-2490, USA, Tel.: (212) 734-5368