A new device for frontal sinus endoscopy: first clinical report

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A new device for frontal sinus endoscopy: First clinical report

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OBJECTIVE: **Endoscopically or microscopically controlled paranasal sinus surgery currently represents the state of the art. For anatomic reasons the ostium of the frontal sinus and the frontal sinus itself are difficult to observe. Flexible endoscopes are often difficult to implement and do not provide enough light intensity to visualize all parts of the frontal sinus.**

MATERIALS AND METHODS: **A specially curved rigid endoscope with a working channel of 1.5 mm that allows passage into the frontal sinus has been developed to manage this problem. The system was used on 15 patients during paranasal sinus surgery to evaluate possible indications and its clinical usefulness.**

RESULTS: **The endoscope could be introduced into the frontal sinus after an ethmoidectomy had been performed in all of the patients. The anatomy of the sinus could be visualized with sufficient light intensity in 14 patients. The shadowing of the frontal sinus seen in CT was not due to polyps of the mucosa of the frontal sinus in all cases, but rather due to secretion with otherwise normal mucosa. In the cases with polyps, it was necessary to irrigate with saline solution to prevent the buoyant polyps from collapsing over the endoscope. The following specific indications for this endoscopic version were established during this first test: intraoperative and postoperative control of the frontal sinus, clinical evaluation of tumor growth into the frontal sinus, biopsies within the frontal sinus, and evaluation of fractures.**

CONCLUSION: **The new device provides further insight within the field.** (Otolaryngol Head Neck Surg 2001;125:613-6.)

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The use of both the microscope and the endoscope in the diagnosis and treatment of nasal and paranasal disorders probably marks the most significant advance in otorhinolaryngology since the introduction of the microscope in otology.[1]

Reichert,[2] in 1902, was the first clinician to use a 7-mm endoscope for the treatment of oroantral fistulas. In 1903, Hirschmann[3] published a report on his instrument, a 5-mm endoscope with a small electric bulb mounted at its proximal end for illumination and diagnosis. Imhofer[4] and Maltz[5] followed in 1910 and 1925 with a sinuscope used mainly for the nose, nasopharynx, and maxillary sinus.

In the 1960s a major technical breakthrough was achieved through the use of fiberoptics and glass fiber cables together with "cold light" sources located outside the endoscope and body. In 1965 the first colored pictures of the maxillary antrum were published, but problems with inadequate illumination and depth of field persisted.[6]

The imaging quality of endoscopes improved with the introduction of a new optics system (Hopkins), and endoscopically controlled paranasal sinus surgery was promoted in different countries by enthusiasts of this technique[7-12] and developed to clinical standards.

The establishment of endonasal surgery of the paranasal sinuses has also decisively influenced the therapy of inflammatory disorders of the frontal sinuses. Implementation of an endoscope, if required in combination with a microscope, eliminates the need in many cases for the external approach.[13] The development of paranasal sinus endoscopy has enabled surgeons to examine the frontal recess and, after conducting a sinusotomy, the medial aspect of the frontal sinus "in most patients." In patients with smaller sinusotomies (4-6 mm in diameter), the frontal sinus cannot be visualized when using 25 or 70 degree wide-angle endoscopes.[14]

Although assessment of the frontal sinus is possible with flexible endoscopes, the literature confirms that inspection of the lateral sections of the frontal sinus is not.[15] The reason for this shortcoming is the poor illumination efficiency of flexible instruments as compared with the light transducers used with rigid endoscopes.

Moreover, the handling of flexible optics and particularly their insertion is often cumbersome and unduly

Fig 1. Endoscope for frontal sinus compared with a frontal sinus suction device.

Table 1. Technical data of the frontal sinus endoscope

Optics image transmission system	10,000 pixels
Viewing direction/angle	0° direct vision
Field of view	70°
Tube/cannula outer diameter	3.0 mm
Working length, total	75 mm
Curved linear section	50 mm
Curved section	25 mm
Radius of curvature	20 mm
Diameter of working channel	1.8 mm

complicated by anatomic factors or intraoperative bleeding and mucus secretion. These circumstances have led to investigations to optimize endonasal frontal sinus endoscopy both from a diagnostic and therapeutic point of view.

MATERIALS AND METHODS

Endoscope (Fig 1)

A rigid curved endoscope with an outer diameter of 3 mm was developed in cooperation with Medisecur Company (Munich, Germany) and STUEMED Company (D-78503 Tuttlingen, Germany). The diameter of the prototype was selected on the basis of clinical experience taking into account the width of the ostium of the frontal sinus determined in anatomic studies as reported in the literature.[16] Moreover, this diameter also allowed the introduction of 10,000 light-transducing optical fibers, an optic and an additional working channel (for alternate irrigation or suction) with a diameter of 1.6 mm. In its present design the instrument resembles a commercial frontal sinus suction device and is inserted according to the usual procedure.

The light cable and the optic can be connected separately, and externally, to a commercial cold-light system or video system. Direct viewing through an eyepiece is also possible. Gas sterilization can be carried out to comply with hygiene regulations. The relevant technical data are compiled in Table 1.

Patients

The endoscope was used in 15 patients (6 women, 9 men; range, 25 to 67 years) who underwent endoscopic paranasal sinus surgery between July and October 1999.

The clinical findings of nasal endoscopy disclosed that 8 patients were free of polyps in the middle meatus or in the main nasal cavity. The CT showed shadowing in the ethmoid area and at least partial opacification of the frontal sinus. In 2 of these patients the frontal sinus appeared completely inconspicuous on CT.

One patient had a mucocele of the frontal sinus that was opened endoscopically, and in another 6 patients 1 nasal polyposis was clinically visible, the CT showing nearly complete opacification of the frontal sinus.

Surgical Procedure

Depending on the pathologic condition shown by CT and on the intraoperative status, either an ethmoidectomy, ethmoidosphenoidectomy, or anterior ethmoidectomy with fenestration of the maxillary sinus was performed initially. Furthermore, in every patient the ostium of the frontal sinus was exposed using the appropriate cutting instruments according to Wigand's method. Further dissection was not carried out in the initial stage, ie, the mucosa was preserved.

The frontal sinus endoscope with a video camera connected was introduced under visual control. During this procedure, alternate irrigation and suction through the working channel could be used to improve visibility. By rotating the endoscope in the frontal sinus ostium, the individual recesses of the frontal sinus and, when retracting the instrument, the frontal sinus ostium itself could be evaluated.

Assessment Criteria

During the first clinical applications of the prototype the following criteria were to be evaluated:

1. Implementation in a surgical/clinical setting,
2. Depth of imaging and optical image quality of the frontal sinus endoscope,
3. Accessibility of the lateral sections of the frontal sinus using the rigid instrument.

Secondary parameters included:

1. Assessment of the frontal sinus mucosa and comparison with clinical findings and diagnostic imaging results (CT),
2. Evaluation of the diagnostic and possible therapeutic options offered by such a new instrument.

RESULTS

The ostium of the frontal sinus could be visualized with the routinely used 70 degree optics in all patients presenting with a varying anatomy. Connection of the frontal sinus endoscope could be carried out within sec-

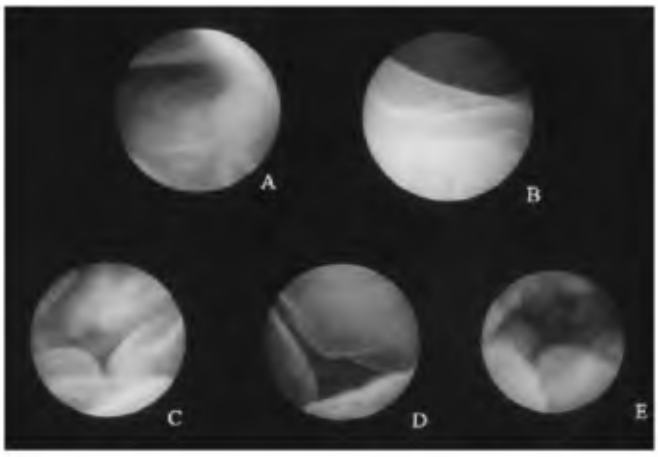

Fig 2. Endoscopic findings: normal frontal sinus mucosa in the lateral part of the frontal sinus. The end of the lateral recess is clearly visible (*A* and *B*); polyps in the frontal sinus before (*C*) and after (*D*) irrigation; edematously changed mucosa in the infundibulum (*E*).

onds and without any problems by the assistant staff. Because of the external attachment of the eyepiece and the light cable, the instrument could be freely guided by the surgeon and handled like a conventional irrigation device. The manual switching from the irrigation to the suction mode was the only problem arising with the prototype.

The passage of the endoscope through the frontal sinus ostium into the frontal sinus was achieved without problems in all patients. Sinuses filled with detritus or blood as a result of the operation first had to be cleared by irrigation and suction. Good to very good visibility together with well-resolved imaging extending even as far as the lateral frontal sinus recess could thus be achieved in 14 of the 15 patients. In one patient the lateral recess protruded far beyond the orbits and thus its boundaries appeared rather dark and unclear and were difficult to assess.

The patients with the opaque or partially opaque frontal sinuses generally showed an inconspicuous or only slightly edematous mucosa that could be visualized and clearly assessed after aspiration of secretions. The anterior and posterior wall of the frontal sinus wall, the orbital roof, the interfrontal septum, the individual recesses and particularly the mucosa in the area of the ostium could be easily assessed. Continuous irrigation with saline solution improved visibility both in these patients and in those with pronounced polypoid changes. The latter condition was noted in only 3 of the 6 patients exhibiting pronounced findings on CT. The 3 other patients showed only moderate edema of the mucosa after an appreciable amount of viscous secretion had been removed. Even in cases of almost complete shadowing of the frontal sinus in the CT, it was possible using the endoscope and irrigation to demonstrate an open lumen. The opacification of the sinus noted on the CT was due to edematous mucosa. In contrast to polypoid changes in the maxillary sinus or in the ethmoid cells, the mucosal changes in the frontal sinuses appeared less compact.

DISCUSSION

Functional endoscopic sinus surgery (FESS) represents a routine method in the treatment of chronic sinusitis.[11] Nevertheless, most reports on frontal sinus surgery are based on the use of 25 or 75 degree endoscopes.

After anterior ethmoidectomy with removal of the anterior insertion of the middle turbinate of the agger nasi has been performed, these endoscopes enable the visualization of the frontal recess and identification of the site of the ostium between the frontal sinus and the ethmoids. A direct view into the frontal sinus is not possible in most cases.

Endoscopy via a Kümmel-Beck borehole[17] and the use of small, flexible endoscopes[13,15] have been mentioned in the literature, but have failed to assert themselves in routine intraoperative application. As far as external access routes are concerned, this may be due to the trend toward minimally invasive surgery and the availability of endoscopic modalities. When deploying the flexible instrument versions, it is no doubt the difficult handling and the lower light yield and poorer resolution associated with the applied technology that restricts its application in clinical routine. In 1996 Weber et al[15] described that an assessment of the later-

al portions of the frontal sinus can be achieved only rarely. On the other hand, the indication for varyingly extensive endonasal frontal sinus operations (Draf type I-III) is established on the basis of radiologic findings. Nonetheless, it is not possible thus far, on the basis of the CT findings, to distinguish between the airless sinus due to fluid or massively hypertrophic mucous membrane.[14] Such recognition is important because the surface of the mucosa must communicate posteriorly with an air passage to permit reversal of mucosal disease.[18]

Thus, the condition of the frontal sinus mucosa determines the extent of endoscopic exposure of the frontal sinus. The first clinical tests have shown that, in contrast to CT and MRI, use of the prototype endoscope allows the surgeon to visualize the actual intraoperative condition of the frontal sinus mucosa and thus decide in favor of either a minor or a major intervention. Apart from the assessment of the mucosa, endoscopy also provides the surgeon with the certainty that the frontal sinus has been opened and not just an ethmoid cell.

In practice, when compared with the flexible endoscopes used before (Wolf Company, 1.6 mm diameter), the rigid frontal sinus endoscope was found to be easier to handle, particularly as far as its passage into the frontal sinus ostium is concerned.

The rigidity of the frontal sinus endoscope allows small bone protrusions to be easily overcome, in contrast to the flexible instrument. The suction and irrigation feature with the integrated working channel enables better visualization and thus prevents a "via falsa." It provides a clearly superior image quality, depth resolution, and light yield when compared with the flexible instrument with the same diameter. Continued improvement in prototype design, eg, switching over to the "suction" mode, will no doubt further improve ease of implementation.

Together with intraoperative applications, postoperative control can be seen as a further prospective indication.

Furthermore, tumor spread into the frontal sinus, as for example in inverted papillomas, can be more easily recognized. Through the working channel biopsies can be retrieved from various locations within the frontal sinus by using microinstruments. Moreover, the application of topical medication in the frontal sinus under direct vision using endoscopic control appears feasible. The evaluation of fractures and rhinoliquorrhea and possibly the endoscopically controlled use of lasers complement the range of indications of this new endoscope development.

CONCLUSION

The newly introduced endoscope offers novel and distinctly improved insights into the frontal sinus and enhanced assessment of the frontal sinus mucosa, including improved evaluation of the lateral sections. With respect to handling and implementation the instrument is easy to operate, particularly in comparison with flexible endoscopes, and it is routinely used for control of the frontal sinus and the ostium of the frontal sinus, both intraoperatively and postoperatively.

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