Techniques in Neurosurgery
Vol. 1, No. 3, pp. 201–212

Endoscope-Assisted Craniotomy

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Abstract: During microneurosurgical procedures lesions or portions of them may be hidden behind unretractable structures. For example, remnants of a craniopharyngioma may be attached to the floor of the third ventricle, parts of a pituitary adenoma may be attached underneath the ipsilateral optic nerve, small remnants of an acoustic neurinoma may be hidden within the fundus of the internal acoustic meatus or vital perforating arteries hidden behind an aneurysm sack. Use of small endoscopes to visualize those structures can avoid the risk of inadvertent surgical injury. Careful and judicious use of endoscopes extends the range of view by minimizing the blind angle under the microscope and lessens the need for extensive dissection and retraction, thus reducing the surgical trauma. With increasing experience endoscopes will be used not only through the same approach as the microscope, but more often through a separate approach, for observation as well as to facilitate dissection of delicate structures. In the near future, endoscope-assisted craniotomy will consolidate its indispensable role in the field of minimally invasive neurosurgery. **Key Words:** Craniotomy—Minimally invasive neurosurgery—Neuroendoscopy—Microneurosurgery—Endoscope-assisted neurosurgery—Cerebral aneurysm—Cerebellopontine angle—Posterior fossa tumors—Acoustic neurinoma—Craniopharyngioma—Pituitary adenoma.

The evolution of neurosurgery has always been marked by attempts to reduce trauma to the brain, the key-stone being 'better visualization'. With ventriculography, angiography, and more recently computed tomography and magnetic resonance imaging, there was an evolution in making structures of the brain visible to the neurosurgeon. The eyes of the neurosurgeon must be able to see these structures to direct instruments towards them. Optical aids for the eyes were used quite early in neurosurgery, e.g., head lamps for better illumination and magnifying glasses to improve visibility of deep structures. Nearly 30 years ago, the introduction of the operating microscope marked the beginning of what is still the gold standard, and what is known as microneurosurgery.

More recently, the combination of further refinements in neuroimaging, the use of computer technology, the revival of stereotactic techniques, the development of endovascular techniques for vascular lesions and the refinements of neurosurgical instrumentation such as small neuroendoscopes, for which the term "minimally invasive neurosurgery" is coined, have been joined for the goals of further minimizing surgical trauma and maximizing surgical results (7).

This report will focus on the use of neuroendoscopes during cranial microneurosurgery, especially during surgery for intracranial aneurysms, for lesions within the sellar region and within the cerebellopontine angle and describe the potential for what I call multi-approach endoscopic microneurosurgery or microsurgical neuroendoscopy, i.e., combining microneurosurgery and neuroendoscopy or even two neuroendoscopes through different approaches.

TECHNICAL CONSIDERATIONS

Besides the usual set-up for microneurosurgical operations, more technical equipment is necessary for en-

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doscope-assisted craniotomy. The neurosurgical operating room is usually already filled with bulky instruments, e.g., the operating microscope, an ultrasonic aspirator, the laser equipment and an increasing number of monitors used by anesthesiologists. All the additional equipment for neuroendoscopy or endoscope-assisted craniotomy has to be managed by the nurses. Nurses have the burden for assembly, maintenance, and sterilization of these refined and fragile technical instruments.

The following is only a partial list of equipment. Neuroendoscopy and endoscope-assisted craniotomy in their present from are still in their infancy, and technical advancement is occurring with amazing speed. Nevertheless, the list can be considered as a basic set to start endoscope-assisted craniotomy:

1. set of small neuroendoscopes
2. light source
3. small, light-weight video camera
4. high resolution video monitor and video recorder
5. picture-in-picture device

Set of small neuroendoscopes

In general, there are lens scopes and fiberscopes in use for neuroendoscopy, ranging in diameter from 4 mm (e.g., the flexible Codman neuroendoscope) to 6 mm (e.g., the Gaab neuroendoscope or the Caemaert encephaloscope) to even 8 mm, with working and flushing channels. For endoscope-assisted craniotomy these endoscopes are undoubtedly too large. There are already commercially available rigid lens scopes with diameters of 2 mm or even less. A 0° lens is not useful because its view is directed in the same direction as the operating microscope. A 30°, 70° or 120° lens can be used, although orientation is somewhat difficult. At present, the best small endoscopes for endoscope-assisted craniotomy are fiberscopes with a rigid shaft and a curved tip. I use three different types.

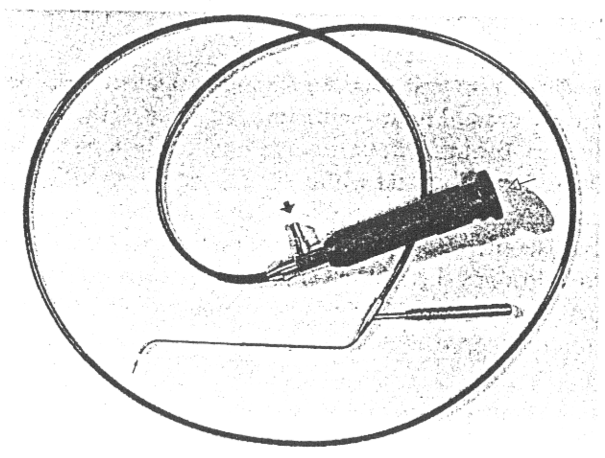

FIG. 1. Neuroscope according to Perneczky with curved optical tip (small arrow), connection for light cable (large arrow), and eyepiece (open arrow).

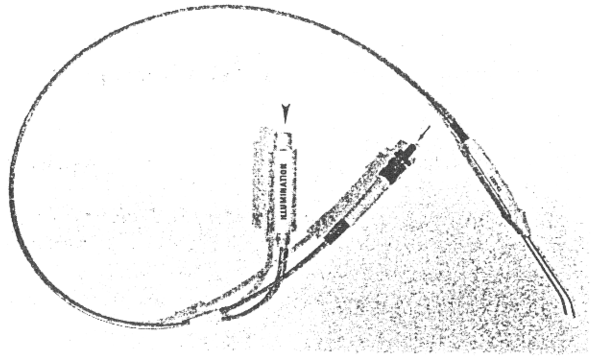

FIG. 2. Otoview Fiber Endoscope with connection for light cable (arrowhead) and video camera (small arrow).

The first one is the Neuroscope according to Perneczky (Aesculap, Tuttlingen/Germany), which is formed like a neurosurgical instrument. It can be considered as a viewing dissector. It has a total length of 1600 mm, a distal diameter of 1.4 mm, a field of view of 80° and a 0° direction of view (Fig. 1).

The second one is the disposable OtoView Fiber Endoscope (Smith & Nephew Richards, Memphis, TN) which is available with a 25° curved tip (Fig. 2). It is nonrepairable with an average life of eight to 12 uses. It has no eyepiece, so the camera is plugged directly to the image cable of the endoscope. The endoscope shaft length is 5.2 cm which is too short in some procedures, but as the name indicates, this 1.4 mm endoscope was primarily designed for otological use. A similar endoscope with a longer shaft is presently in preparation.

The third one is the Neuroview700-2.3 mm Neuroendoscope (Neuro Navigational, Costa Mesa, CA) which is a single use disposable endoscope that has a 25.0 cm flexible shaft and a 1.9 cm deflecting tip with a 90° unidirectional angle of articulation (Fig. 3)It is equipped with a 1.0 mm working channel through which small instruments such as a grasping forceps or bipolar electrode can be introduced.

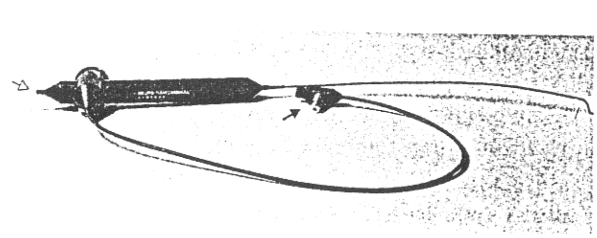

FIG. 3. Neuroview 700-2.3 mm Neuroendoscope with connections for light cable and video camera (large arrow), deflectable tip (small arrow), and entrance of working channel (open arrow).

Light source

Illumination should be provided by a cold light source, preferably a xenon light of so-called daylight intensity. This is the light source that generally is used for operating microscopes. For the small endoscopes used in endoscope-assisted craniotomy, a light source that automatically adjusts the brightness and the light intensity is very helpful (Fig. 4). This will maintain an optimal image while the endoscope is moved.

Small, lightweight video camera

As the video camera is mounted on the eyepiece of the neuroendoscope, it should be as small and as light as possible. Because the quality of the image depends upon the quality of the camera it should be a CCD-color-camera, which assures the best possible picture (Fig. 5) I presently use a 1/2" CCD-color-camera TR 5130 3-Lux (Smith & Nephew Richards, Memphis, TN, U.S.A.) with a diameter of 17 mm, a length of 38 mm, and a weight of only 16 g. For endoscope-assisted craniotomy it is essential that the connection between image cable or eyepiece with the camera is far out of the operating field so as not to be in the way.

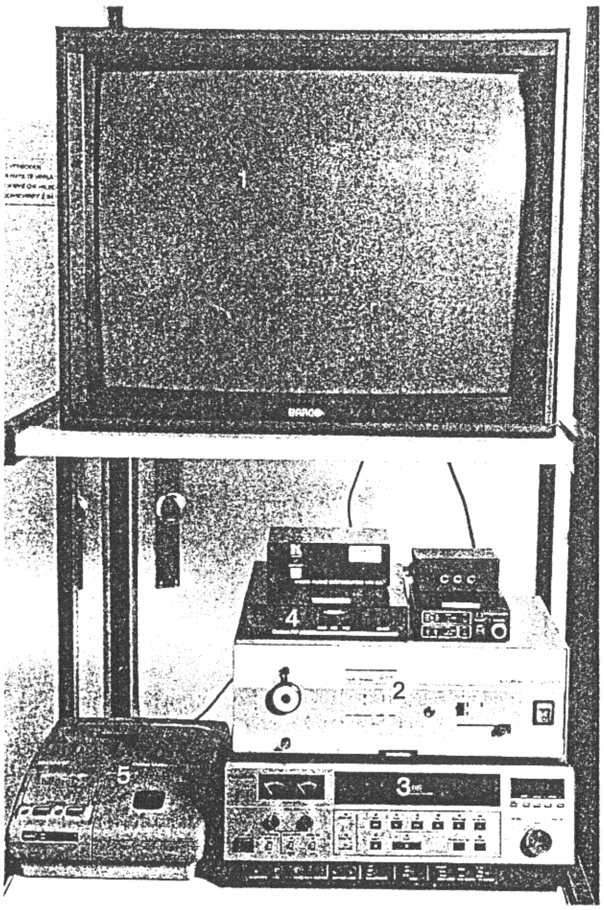

FIG. 4. Additional equipment in use for endoscope-assisted craniotomy. 1, video monitor; 2, light source with self-adjustable brightness; 3, videorecorder; 4, picture-in-picture device; 5, video printer.

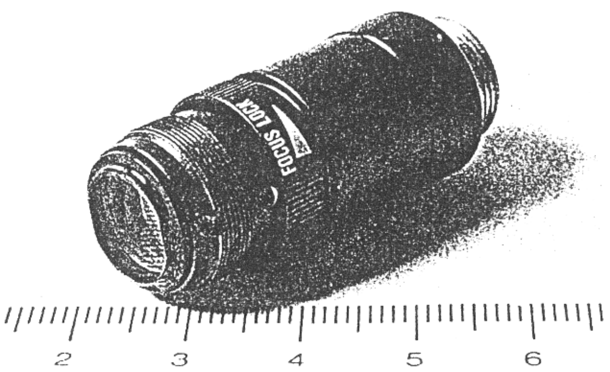

FIG. 5. CCD-Color-Camera TR 5130 3-Lux.

High-resolution video monitor and video recorder

The video monitor is an important part of the equipment because all pictures are displayed on it. It should have a high resolution and correct color balance (Fig. 4). It should not be too small so it can be placed at a sufficient distance to maintain sterility of the operating field. It should be large enough so one can see all necessary details. The operation should be recorded on a video recorder (Fig. 4). Sometimes it is useful to rewind the cassette and review parts of the endoscopic inspection even several times, e.g., to ensure that the aneurysm clip is correctly positioned. Otherwise, it is a documentation of what has been done during the operation, which is useful for teaching purposes as well as from a legal point of view.

Picture-in-picture device

One of the major inconveniences in endoscope-assisted craniotomy is that one has to discontinue the microscopic inspection to look at the video monitor that displays the endoscopic image. At that moment one has no control over the position of the endoscope with regard to surrounding brain structures. To solve this problem, one possibility is to develop an overlay display for the operating microscope (4,9) although even then it is very difficult to look at both pictures simultaneously, aside from the difficulty with this technique in maintaining color balance of both pictures. A simple makeshift is the use of a picture-in-picture device connected to the video monitor (Fig. 4). It allows overview of both the microscopic and endoscopic pictures, either one of which pictures can be enlarged.

ENDOSCOPE-ASSISTED CRANIOTOMY

The concept of minimally invasive neurosurgery is to reduce the extent of various approaches. This is made possible by specific, tailored planning of each procedure based upon a construction of the individual anatomy as provided by preoperative neuroimaging methods. To exploit this fully requires use of a new visual dimension (8). This generally applicable new dimension in neurosurgery is termed neuroendoscopy (8). Although the more commonly recognized use of neuroendoscopes is within the ventricular system, these devices also provide a new visual dimension when used within the subarachnoid space along the entire surface of the brain and spinal cord during microneurosurgical procedures; hence, it is referred to as endoscope-assisted microneurosurgery or, when applied to the neurocranium, endoscope-assisted craniotomy.

Orienting the neuroendoscope within the subarachnoid space demands completely new points of reference, that are difficult to relate to the more familiar microneurosurgical topography (8). Thorough study of the endoscopic anatomy of the subarachnoid spaces should precede the application of endoscope-assisted craniotomy if one is to take maximum advantage of its possibilities. To exemplify what endoscope-assisted craniotomy can offer, the most common applications will be discussed in detail.

ENDOSCOPE-ASSISTED CRANIOTOMY WITHIN THE SELLAR REGION

The most common lesions encountered in this region are pituitary adenomas, meningiomas, craniopharyngiomas and less frequently gliomas of the optic pathways or of the hypothalamus. All these lesions lead to displacement of the structures within the sellar region, such

A B C

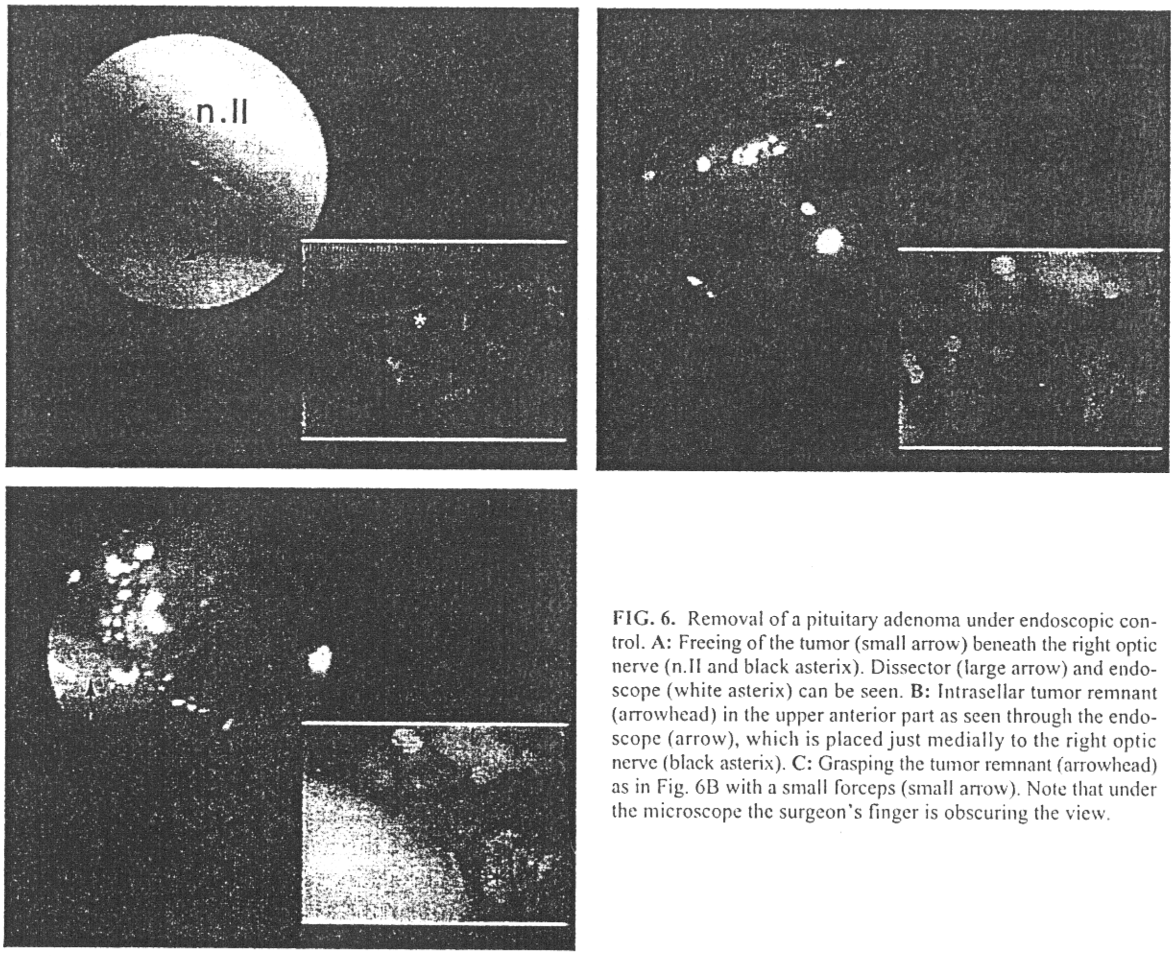

FIG. 6. Removal of a pituitary adenoma under endoscopic control. A: Freeing of the tumor (small arrow) beneath the right optic nerve (n.II and black asterix). Dissector (large arrow) and endoscope (white asterix) can be seen. B: Intrasellar tumor remnant (arrowhead) in the upper anterior part as seen through the endoscope (arrow), which is placed just medially to the right optic nerve (black asterix). C: Grasping the tumor remnant (arrowhead) as in Fig. 6B with a small forceps (small arrow). Note that under the microscope the surgeon's finger is obscuring the view.

as the optic nerves, the optic chiasm, internal carotid arteries and their branches, anterior cerebral arteries and the anterior communicating artery, the upper basilar artery and origin of both posterior cerebral and superior cerebellar arteries, the oculomotor nerves, pituitary gland and stalk, and the adjacent hypothalamus.

Depending on the exact site and size of a lesion, several approaches can be used, e.g., a subfrontal, frontolateral, pterional, or transsphenoidal approach. All these approaches do have their blind corners, e.g., from a frontolateral or pterional approach it is difficult or even impossible to see underneath the ipsilateral optic nerve, or the medial-posterior part of the internal carotid artery or the pituitary stalk without excessive retraction. The anterior and ipsilateral part of the sellar contents and the structures posteroinferior to the optic chiasm also cannot be seen sufficiently. From a transsphenoidal approach it is impossible to control parasellar structures, even when the sellar diaphragm is deliberately opened, but endoscopes can overcome this difficulty (1,6).

The variety of viewing angles gained by using endoscopes allows the operator an overview of the entire sellar region. By using the 'viewing dissector' in one hand which provides the possibility of seeing otherwise hidden structures, specific instrumental manipulation with both hands has become possible (Fig. 6).

ENDOSCOPE-ASSISTED CRANIOTOMY AROUND THE PETROUS PYRAMID

The petrous pyramid, a wedge-shaped bone embedded in the base of the skull, constitutes a burly obstacle for surgical approaches to peripetrous lesions. The petrous bone can be considered a quadrangular pyramid with two intracranial and two extracranial surfaces, but because the standard lateral view of the skull gives an impression that is roughly triangular, in most instances only three surfaces, superior, posterior and inferior (the base being the mastoid), are described.

The vertical nature of the posterior surface of the petrous bone, especially as it is buried in the dihedral angle it forms with the tentorium, together with the vicinity of the pons, the course of the dural sinuses and the cranial nerves traversing towards their respective foramina, make exposure of this region particularly constricted and arduous. Lesions most commonly encountered in this peripetrous region, most of them found in a somewhat more restricted area referred to as the cerebellopontine angle, are acoustic neurinomas, meningiomas and, less frequently, cholesteatomas and chordomas. Other lesions that lead to neurosurgical exploration of this region are vascular compressions of cranial nerves, leading to trigeminal neuralgia or hemifacial spasm. Vestibular neurectomy is also carried out in this region to treat vertigo.

Within the prism-shaped cerebellopontine angle, three closed cisterns can be recognized. The cerebellopontine cistern, containing the trigeminal nerve, facial and acoustic nerves, anterior inferior cerebellar artery and its main branches as well as the accessory meatal branch and the petrosal vein and its branches, the lateral cerebellomedullary cistern, containing the glossopharyngeal nerve, vagus nerve, accessory nerve, hypoglossal nerve, posterior inferior cerebellar artery, lateromedullary veins and veins of the cerebellar amygdala and lateral recess, and the prepontine cistern, containing the abducens nerve, basilar artery trunk and origin of both anterior inferior cerebellar arteries, and the transverse and median pontine veins.

Tumors in this region can become very large before they are diagnosed. Often they fill up one of these cisterns and compress the other two, so it is very difficult to create a space that will allow endoscopic inspection of this region. In these cases it is generally necessary to first debulk and partially remove the tumor and then use the endoscope. For example, when using the suboccipital retromastoid approach for an acoustic neurinoma it is difficult to see the fundus of the internal acoustic meatus entirely. This part of the operation is aided by use of the endoscope, and small tumor remnants can be removed under endoscopic control. In vascular compression syndromes or in the event of a planned vestibular neurectomy (5), normal cisternal anatomy is maintained, which allows sufficient space for endoscope-assisted craniotomy (Fig. 7).

ENDOSCOPE-ASSISTED CRANIOTOMY FOR INTRACRANIAL ANEURYSMS

Aneurysm surgery has benefitted significantly from introduction of the operating microscope, and subsequently the results of operative repair of intracranial aneurysms has shown major improvement, best illustrated by referring to the work of Yasargil (10). Nevertheless, there are still ample technical difficulties with aneurysms in certain locations, especially in posterior circulation aneurysms.

I have used small endoscopes in all aneurysm cases during the past three years and with increasing experience it was possible to improve and reduce the operative approach and optimize clip application. I am convinced that the operative repair of intracranial aneurysms is an excellent indication for endoscope-assisted craniotomy.

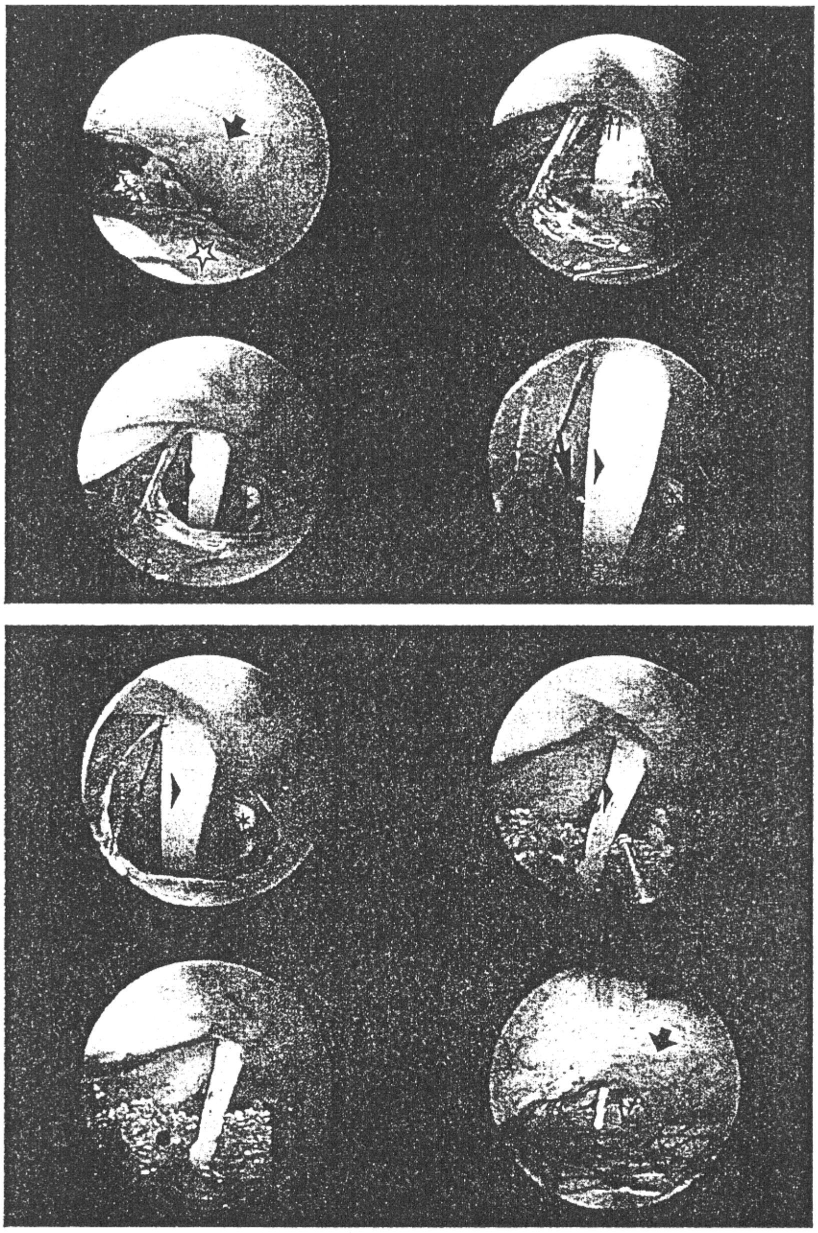

FIG. 7. Endoscopic view of the cerebellopontine angle in a case of hemifacial spasm with acoustic-facial nerve group (arrowhead), arachnoid of the cerebellopontine cistern (small arrow), the internal acoustic meatus (double arrow), trigeminal nerve, partially covered by the petrosal vein (black asterix), loop of anterior inferior cerebellar artery (large arrow) compressing the facial nerve, Ivalon sponge (black dot) between arterial loop and facial nerve, and cerebellum (open asterix) with tentorium (small thick arrow).

SPECIFIC LOCATIONS

Anterior communicating artery aneurysms

The anterior communicating artery (ACoA) is a variable structure and angiography often does not reveal its complex anatomy in cases of ACoA-aneurysms. As known from the work of Yasargil (10), as a rule an aneurysm of the ACoA will arise from the side of the ACoA that receives the larger A1 segment of the anterior cerebral artery (ACA) when the proximal ACA's are unequal, and will arise from the midportion of the ACoA when the proximal ACA's are equal. This rule also can be applied to the position of the small hypothalamic arteries that take their origin from the ACoA. These arteries arise from the side of the ACoA toward the larger A1 segment. Therefore, one should remember that these arteries usually are hidden just under the origin of the aneurysm and will be adherent to the aneurysm sack when the fundus of the aneurysm projects antero-inferiorly or postero-inferiorly. After initial dissection of the region of an ACoA aneurysm, endoscopic inspection will reveal much of its complex anatomy and will alleviate further preparative dissection for clipping (Fig. 8). The necessity for subpial resection of the gyrus rectus

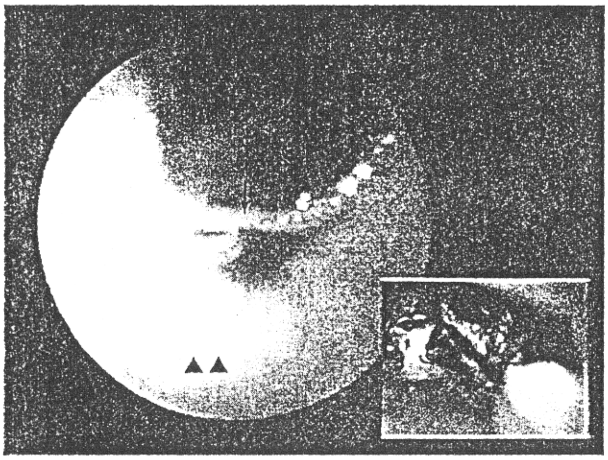

FIG. 8. Endoscopic view (larger picture) and microscopic view (smaller picture) using picture-in-picture device in a case of anterior communicating artery (ACoA) aneurysm. Hypothalamic artery (arrow) underneath ACoA complex (double arrowhead).

can be reduced. By using the endoscope following clip application, it is not necessary to manipulate the clip itself to inspect its proper position.

Posterior communicating artery and anterior choroidal artery aneurysms

It is often very difficult to distinguish posterior communicating artery (PCoA) aneurysms and anterior choroidal artery (AChoA) aneurysms angiographically because of the diversity in number and descent of internal carotid artery (ICA) branches. In PCoA aneurysms endoscopic inspection between optic nerve and medial side of the ICA after opening of the carotid and interpeduncular cisterns will uncover the course of the PCoA and the thalamoperforating tributaries as well as the medial extension of the aneurysm toward the oculomotor nerve. In AChoA aneurysms the course of the artery itself into the crural cistern can be seen with the endoscope, along with branches to the uncus and any adhesions between the fundus of the aneurysm and the mesial temporal lobe. The position of the tip of the clip blades can best be appreciated by endoscopic inspection.

Internal carotid artery bifurcation aneurysms

Many of these aneurysms are quite large and often broad-based. Around the area of the ICA bifurcation several cisterns, such as the carotid, Sylvian, olfactory and lamina terminalis cisterns and also crural and interpeduncular cisterns, converge. Several small arteries must be identified during operation for ICA bifurcation aneurysms. These include the medial and lateral striate arteries from the ACA and the middle cerebral artery (MCA), the recurrent artery of Heubner and the diencephalic branches from the PCoA and AChoA. All these small arteries are usually found on the posterior wall of the aneurysm (although in some cases I found small arteries like a recurrent artery of Heubner running over the anterior aspect of the aneurysm).

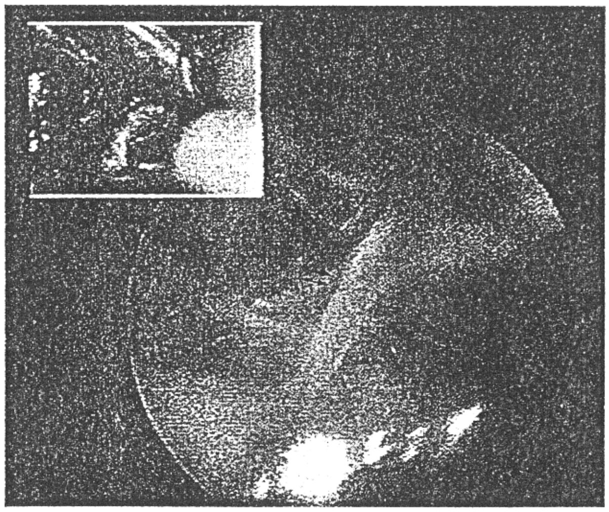

FIG. 9. Endoscopic inspection in a case of left internal carotid artery (ICA) bifurcation aneurysm. Position of endoscope (large arrow) is lateral to left ICA (small arrow). Small perforating artery (double arrow), attached to the posterior part of the aneurysm sack (arrowhead).

Initial endoscopic inspection is done after opening of the carotid cistern medially and laterally from the ICA and exposure of the origin of the PCoA and the AChoA. The course of these arteries and their branches toward the aneurysm and their possible adherence to the fundus, is recorded. Following further dissection of the lamina terminalis and Sylvian cisterns, and identification of the course of the ACA and MCA and identification of the recurrent artery of Heubner and any of the striate arteries, the posteroinferior region of the aneurysm should be inspected endoscopically (Fig. 9). Before the use of endoscopes, this region could only be inspected by retraction of the aneurysm itself, often only after opening of the pia mater of the orbitobasal frontal lobe and resection of a few millimeters of subpial tissue, or by temporary clipping, and puncture and collapse of the aneurysm sac. Any adherent artery can be released under endoscopic control. After clipping, the position of the tip of the clip blades can be checked reliably (Fig. 10) without further manipulation of the clip or the arteries.

Middle cerebral artery aneurysms

MCA aneurysms are contained within the Sylvian cistern and are enclosed by the opercula of the frontal, parietal and temporal lobes. Use of endoscopes is very

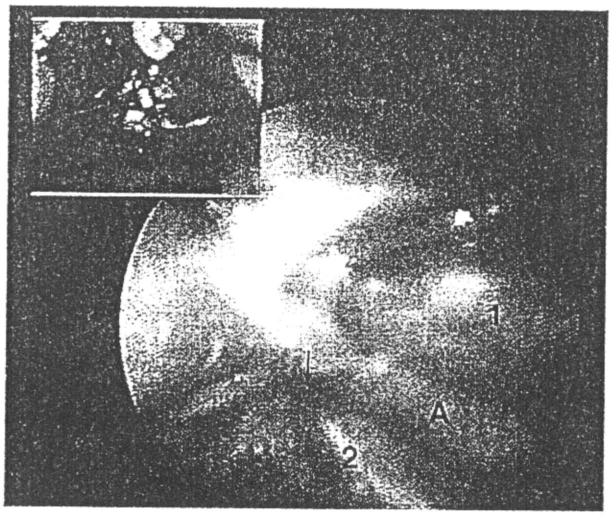

FIG. 10. Endoscopic view of the same case of left ICA bifurcation aneurysm (A) as in Fig. 9 following application of two clips (1 and 2). Note that the tip of the blades of the second clip (arrow) just includes one of two small arteries (double arrow) and this prompted repositioning of the clip.

limited in MCA aneurysms. It sometimes can be helpful to control the position of the clip blades by inspecting between the M1 segment and the superior M2 trunk with the tip of the endoscope directed towards the aneurysm and the inferior M2 trunk. This avoids manipulation of the clip itself. This is done only just before

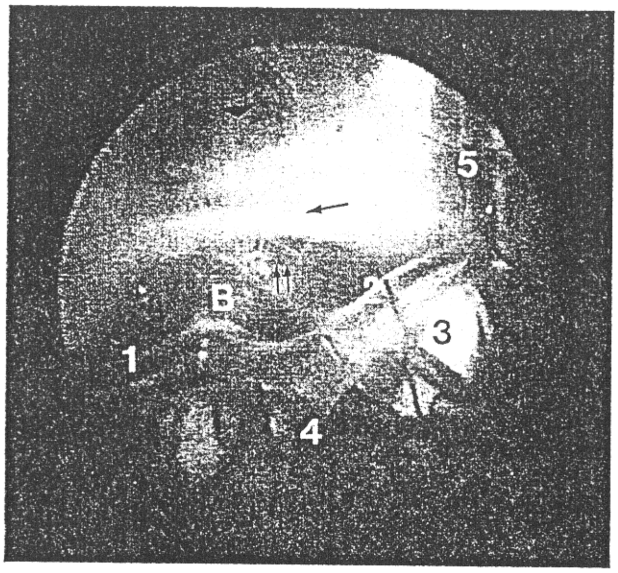

FIG. 11. Overview of basilar artery (BASA) anatomy as seen through an endoscope during third ventriculostomy in a 4-month-old child with obstructive hydrocephalus. B, BASA; 1, left posterior cerebral artery (PCA); 2, right PCA; 3, right oculomotor nerve; 4, complex of perforating arteries at the posterior aspect of the BASA; 5, right posterior communicating artery; arrow, dorsum sellae; double arrow, prepontine cistern; arrowhead, pituitary gland.

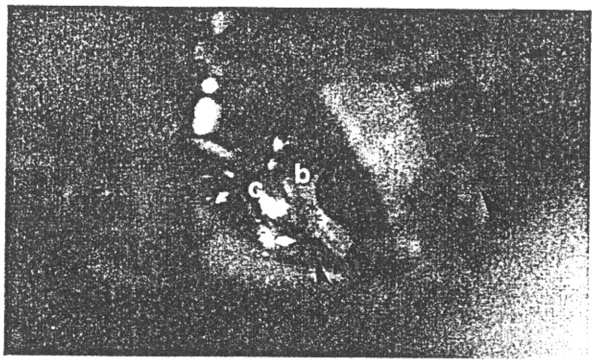

FIG. 12. Clip on BASA bifurcation aneurysm. 1, interoptic prechiasmatic approach; 2, opticocarotid approach; 3, carotidoculomotor approach (note tip of endoscope *); 4, lateral oculomotor-subtentorial approach; b, BASA; c, clip.

puncture and collapse of the aneurysm, which will allow definitive inspection around the MCA bifurcation.

Basilar artery bifurcation aneurysms

Located deep within the interpeduncular cistern, these aneurysms are, together with those of the basilar artery (BASA) trunk probably the most challenging lesions in neurosurgery. For no other type of lesion is the value of endoscope-assisted craniotomy as convincing as for the treatment of BASA aneurysms. The anatomy of the BASA bifurcation will become much more familiar as one performs endoscopic anatomical studies and third ventriculostomies (Fig. 11). The anterior surface of the BASA is free of perforators. The paramedian perforators arise from the posterior and lateral surfaces of the BASA. Together with the medial perforating artieries from the P1 segment of the posterior cerebral artery

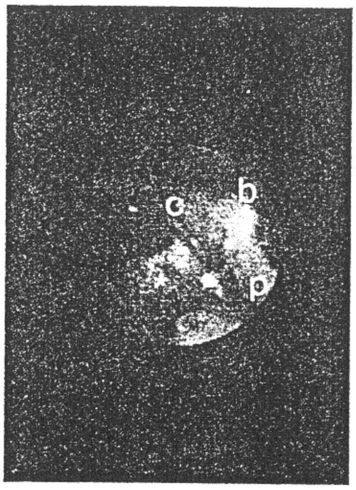

FIG. 13. Clip (c) on BASA (b) bifurcation aneurysm (white asterix) as seen through a small flexible endoscope through an opticocarotid approach. Right posterior cerebral artery (p) can be seen.

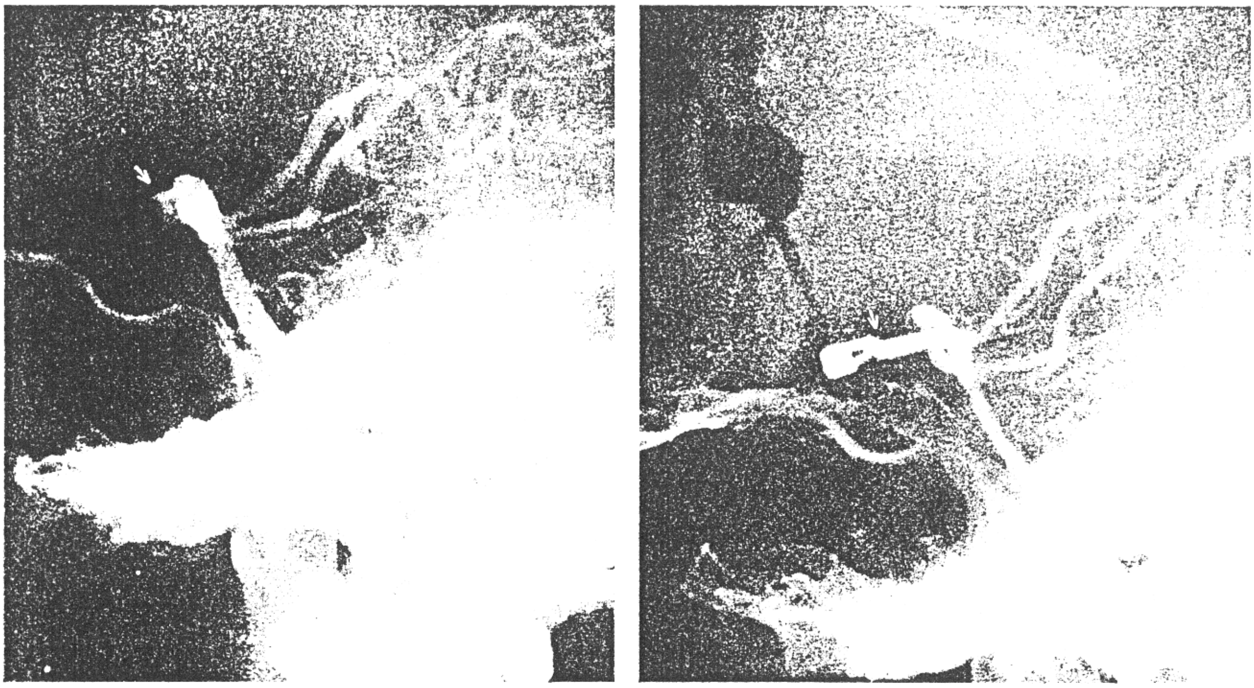

FIG. 14. **A:** Angiogram of the aneurysm (arrow) shown in Fig. 13 before clipping. **B:** Postoperative angiogram with position of the clip (arrow).

(PCA) they form a puzzling arterial network in the interpeduncular fossa.

After initial dissection with opening of all parasellar cisterns and the interpeduncular cistern, the entire anatomy around the BASA bifurcation aneurysm is studied endoscopically. Even routes that are too small to use for further microsurgical dissection can be approached with the endoscope, e.g., interoptic prechiasmatic, opticocarotid, carotidoculomotor and sometimes even a lateral oculomotor-subtentorial approach can be used (Fig. 12). After further delineation of the BASA area and the aneurysm, closer endoscopic inspection around the aneurysm will clarify its intimate relation to the PCA. Microscopically, the ipsilateral PCA can be seen quite easily while the opposite PCA is hidden. The endoscope will offer visualization of this region. Nevertheless, application of a clip in BASA bifurcation aneurysms remains a strenuous maneuver. Often clips with relatively long jaws are necessary because the applying or removing forceps in the deep and narrow space obscures the aneurysm clip. After clip application, the clip itself will obscure the previous working space and control of the correct position of the tip of the clip blades is very difficult. Usually, the clip has to be moved in several directions to catch a glimpse of the clip blades. With the use of endoscopes, this is no longer necessary, as endoscopes offer the possibility of reliable verification of the clip position (Figs. 13 and 14).

Upper basilar artery trunk aneurysms

Many of what is said about BASA bifurcation aneurysms applies to aneurysms of the upper basilar trunk. These aneurysms most often arise between the origin of the PCA and the superior cerebellar artery (SCA) and project laterally, always affecting the ipsilateral oculomotor nerve. A pterional approach with a somewhat more temporal extension is used to approach these aneurysms. The entire anatomy and all adhesions around the aneurysm due to the subarachnoid hemor-

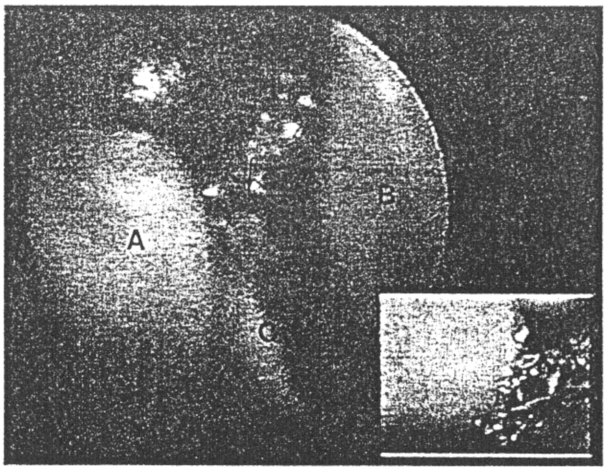

FIG. 15. Tip of the clip (C) blade (arrow) on a lateral BASA trunk (B) aneurysm (A).

A, B

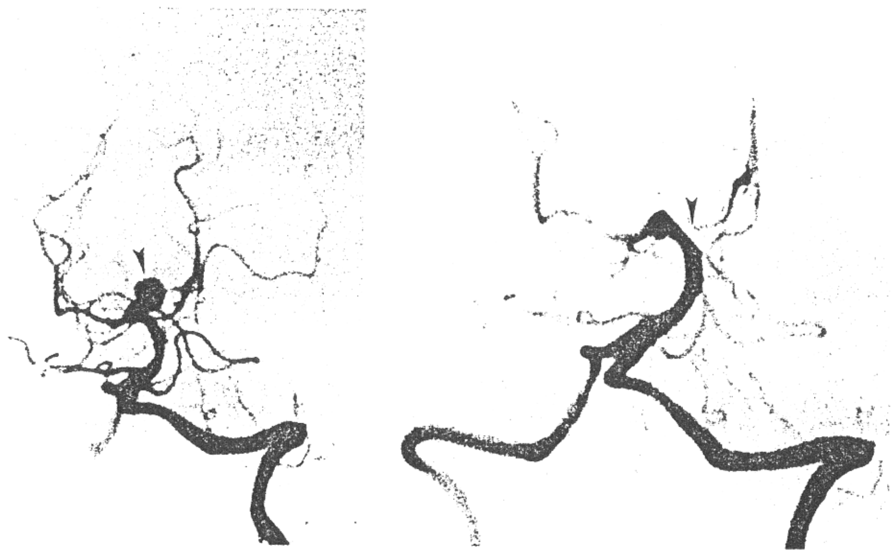

FIG. 16. A: Angiogram of the aneurysm (arrow) as shown in Fig. 15 before clipping. B: Postoperative angiogram with position of the clip (arrow).

rhage can be appreciated by using the endoscope. The clip position can also be seen (Figs. 15 and 16).

MULTI-APPROACH ENDOSCOPIC MICRONEUROSURGERY

Although endoscope-assisted craniotomy offers visualization of otherwise hidden structures, sometimes it is still difficult to dissect these structures through the chosen microneurosurgical approach. With increasing experience in endoscope-assisted craniotomy it came to mind that approaching a certain lesion from different sides could be beneficial. A prerequisite for the technique of multi-approach endoscopic microneurosurgery is the availability of small yet multifunctional neuroendoscopes that not only offer the possibility of observation but also allow dissection and coagulation. It became possible to approach deep-seated lesions by two different trajectories, either with two endoscopes or by combining a microneurosurgical approach with a second endoscopic one. Neuroendoscopes with diameters up to 6 mm are suitable for this purpose. This multi-approach endoscopic microneurosurgery (or microsurgical neuroendoscopy) has been used in the treatment of paraventricular tumors,

A B

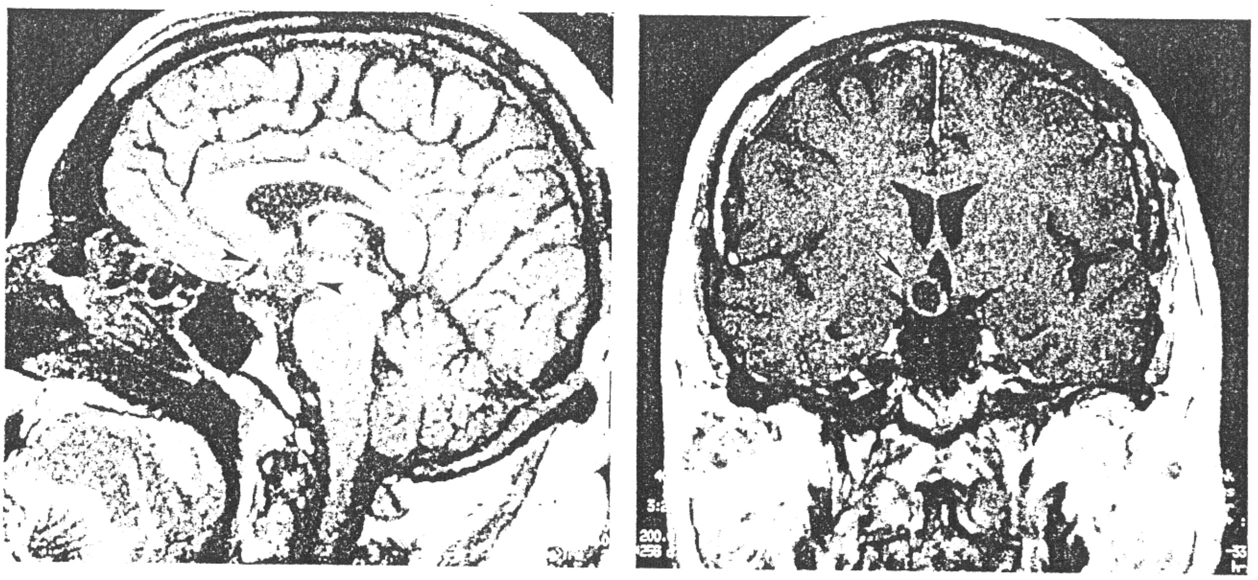

FIG. 17. A: Preoperative sagittal MRI-scan of the case shown in Figs. 17–19. Position of tumor shown between arrows. B: Preoperative coronal MRI-scan. Arrow points to the tumor, partially within and partially outside the third ventricle.

A B

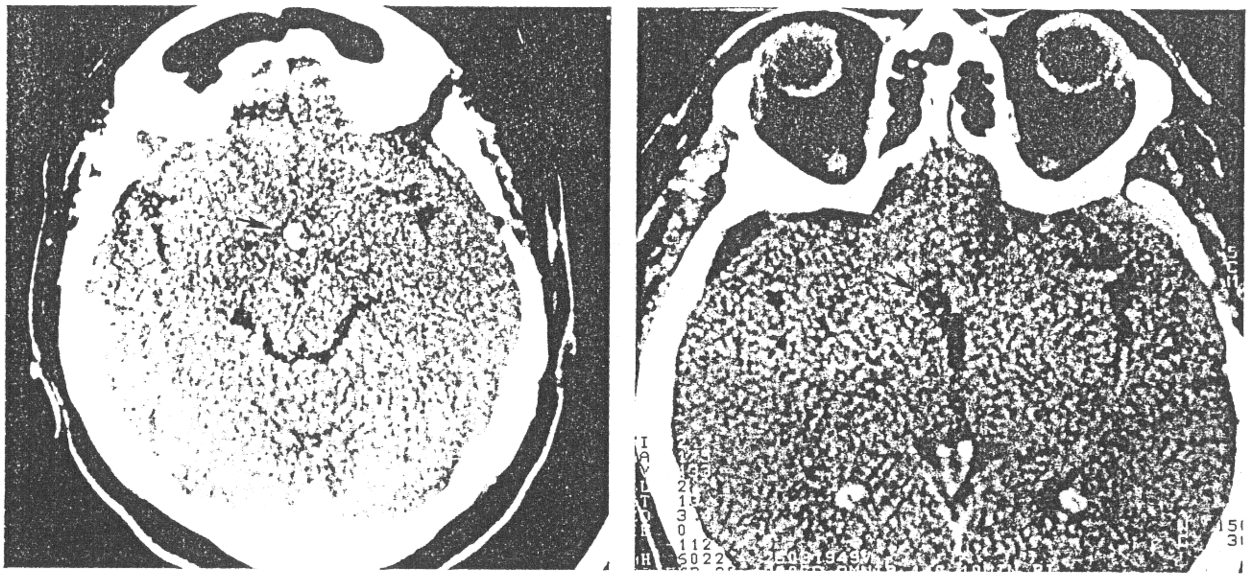

FIG. 18. A: Preoperative CT scan of the case as shown in Figs. 17–20 showing the calcified tumor (arrow). B: Postoperative CT-scan of the same case [note the hypodensity at the former site of the calcified tumor (arrow)].

tumors of the cerebellopontine angle, craniopharyngiomas and pituitary adenomas. The use of this technique is best exemplified by describing a case.

In a case of recurrent craniopharyngioma, regrowth occurred within the floor of the third ventricle, just lateral to the midline on the right, in front of the mamillary bodies and posterior to the infundibular recess, growing downward between both optic tracts (Fig. 17). CT-scan showed that the tumor was calcified (Fig. 18A).

A right-sided frontolateral-basal approach was combined with a left-sided endoscopic transventricular approach to the third ventricle. First the tumor was exposed endoscopically. This showed the calcified part within the floor of the third ventricle (Fig. 19). Then the tumor was exposed through a right-sided frontolateral-basal approach and dissected free from the posterior part of the chiasm, both optic tracts, the anterior communicating and right anterior cerebral artery microneurosurgically while constantly observing the intraventricular part. Then this latter part was dissected through the endoscope using a bipolar electrode. It was freed from the floor of the third ventricle (Fig. 20). The tumor could then be removed from the frontolateral-basal approach. Inspection with the endoscope showed a small tumor remnant underneath the right optic tract that could be removed (Fig. 21). Further inspection con-

A, B

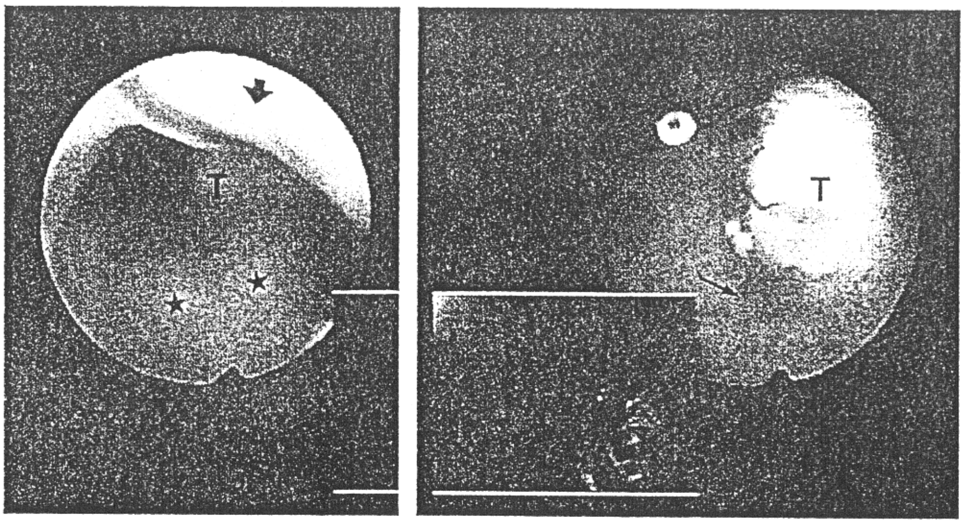

FIG. 19. Endoscopic view of small recurrent craniopharyngioma within the floor of the third ventricle. A: View at the left foramen of Monro with fornix (thick arrow), mamillary bodies (asterix), calcified tumor part (T) and floor of the third ventricle (small arrow). B: Closer view of calcified tumor (T) within the floor of the third ventricle (small arrow).

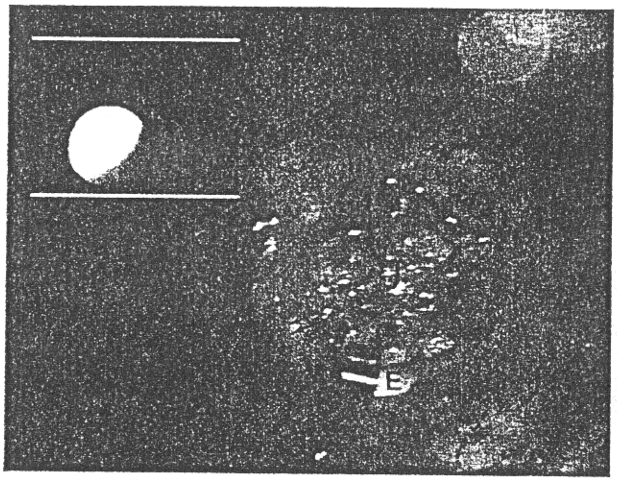

FIG. 20. Endoscope (E) protruding out of the floor of the third ventricle after nearly completely freeing of the tumor (T). Left optic tract (black asterix), posterior margin of optic chiasm (Ch), right optic tract (open asterix), and anterior cerebral artery (double arrow) are visible.

firmed total removal. This was also documented by immediate postoperative CT scan (Fig. 21B).

DISCUSSION

The concept of minimally invasive neurosurgery has evolved from developments in neurosurgical instrumentation, computer technology, robotics, navigation systems, and neuroimaging that allow preoperative visualization of the individual patient's anatomy and thus tailored surgical planning. The possibilities offered by modern neuroendoscopes fit perfectly in these minimally invasive trends in neurosurgery, although we should realize that our predecessors already used endoscopes 75 years ago. Recent refinements in optics and surgical instrumentation have made neuroendoscopic procedures safe. Combining the different minimally invasive techniques has even further improved the results of neurosurgical efforts. Examples of this are combining microneurosurgery and endovascular techniques for the treatment of cerebrovascular malformations, and the joining of stereotaxy and radiotherapy, which has led to what we now call stereotactic radiosurgery.

In endoscope-assisted craniotomy the ability of neuroendoscopes to provide a great variety of viewing angles allows one to visualize extended regions of the brain surface and its subarachnoid spaces, complementary to those seen by the operating microscope. This offers new operative strategies for the treatment of many kinds of intracranial lesions. The combination of microneurosurgery and neuroendoscopy, using either the same operative approach or using different approaches, helps to minimize the disadvantages of each and maximizes the benefit to our patients.

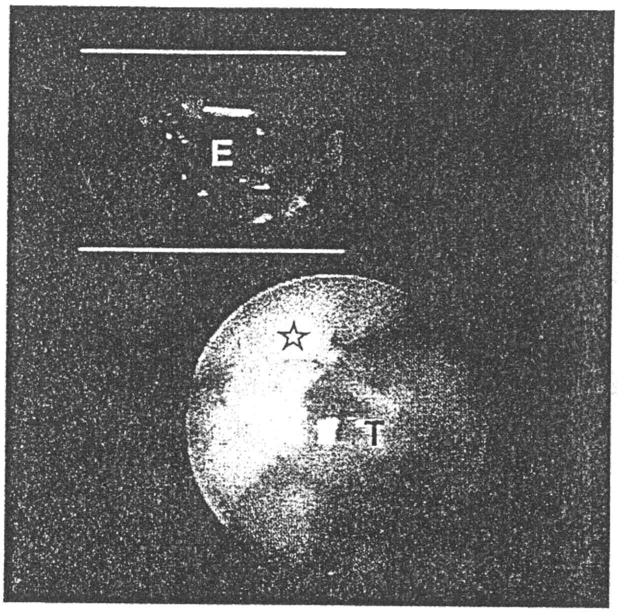

FIG. 21. Small tumor remnant (T) attached to the right optic tract (open asterix) as visible through the endoscope (E).

Acknowledgment: This article is dedicated to Prof. Dr. W. Bettag, my teacher in neurosurgery, on the occasion of his 70th birthday. I want to thank Prof. Dr. A. Perneczky for guiding my way into the field of minimally invasive neurosurgery.

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