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[Clinical Studies]

Endoscope-assisted Brain Surgery: Part 2-Analysis of 380 Procedures

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Abstract

OBJECTIVES: Microsurgical techniques and instruments that help to reduce intraoperative retraction of normal intracranial neuronal and vascular structures contribute to improved postoperative results. To achieve sufficient control of the operating field without retraction of neurovascular components, the resection of dura and bone edges is frequently required, which, on the other hand, increases operating time and operation-related trauma. The use of endoscopes may help to reduce retraction and, at the same time, may help to avoid additional dura and bone resection. The aim of this study is to describe the principles on which the technique of endoscope-assisted brain surgery is based, to give an impression of possible indications for endoscope-assisted microsurgical procedures, and, with illustrative cases, to delineate the advantages of endoscopes used as surgical instruments during microsurgical approaches to intracranial lesions.

METHODS: During a period of 4.5 years, 380 microsurgical procedures were performed as endoscope-assisted microneurosurgical operations. This surgical series was analyzed for time of surgery, usefulness of intraoperative endoscopy, and complication rates. Lens scopes with viewing angles of 0 to 110 degrees and with diameters of 2.0 to 5.0 mm as well as newly designed "viewing dissectors" (curved, rigid fiberscopes) with diameters of 1.0 to 1.5 mm connected to a video unit were used as microsurgical instruments. The positioning of the endoscopes was achieved by retractor arms fixed to the Mayfield headholder. Thus, the surgeon was able to perform customary microsurgical manipulations with both hands under simultaneous endoscopic and microscopic control.

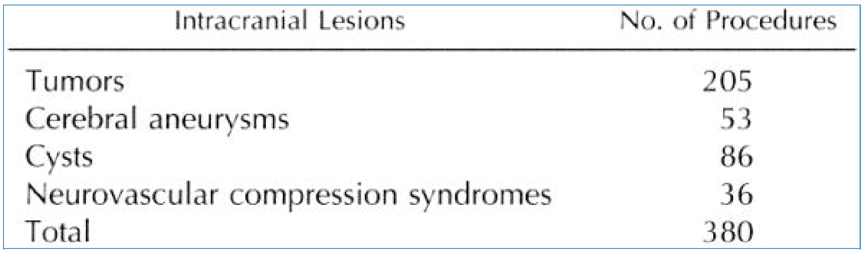
RESULTS: The lesions treated with endoscope-assisted microsurgery comprised 205 tumors, 53 aneurysms, 86 cysts, and 36 neurovascular compression syndromes. Eighty-nine of these lesions were localized in the ventricular system, 242 in the subarachnoid space or intracerebral, and 49 in the sella. Endoscope-assisted microsurgery was advantageous to reduce the size and the operation-related tissue trauma of approaches to lesions within the ventricular system, in the brain tissue as well as in the subarachnoid space at the base of the brain. Using less retraction during tumor removal, the visual control of retrosellar, endosellar, retroclival, and infratentorial structures was improved. Video-endoscope instrumentation was especially helpful during procedures in the posterior cranial fossa and at the craniocervical junction. It allowed for inspection of channels and hidden structures (e.g., the internal auditory meatus, the ventral surface of the brain stem, the ventral aspect of root entry zones of cranial nerves, the content of the foramen magnum, and the upper cervical canal), both without retraction and without resection of dura and bone edges. Endoscope instrumentation during surgery for large or giant aneurysms was useful to dissect perforators on the back side of the aneurysms and to control the completeness of clipping.

CONCLUSION: Although the results reported herein cannot be compared directly with those of exclusive microsurgical procedures performed during the same period of time, videoendoscope-assisted microsurgery can be recommended as a time-saving, trauma-reducing procedure apt to improve postoperative outcomes.

Intraoperative retraction of brain tissue causes an increase of local cerebral tissue pressure and a decrease of regional cerebral blood flow (1,10,14,22). These conditions may lead to cerebral infarction. In addition, the retraction of cranial nerves or subarachnoid vessels may damage these structures. All such retraction-related damage induced in brain tissue, cranial nerves, and vessels is caused by the surgical procedure itself and not by the lesion being treated. This surgery-related traumatization may impair postoperative results after microneurosurgical procedures. Microsurgical techniques and instruments that help to reduce intraoperative retraction of normal intracranial neuronal and vascular structures contribute to improved postoperative results. To achieve sufficient control of the operating field without the necessity of retraction of neurovascular components, the resection of dura and bone edges is frequently required. This step, on the other hand, prolongs the operating time and increases operation-related trauma. The intraoperative use of endoscopes may help to reduce retraction of brain tissue, cranial nerves, and brain vessels (4,11,13,18-20) and, at the same time, may help to avoid additional dura and bone resection. We therefore evaluated the usefulness, ease of integration into the standard surgical system, and safety of videoendoscopy in a series of microsurgical intracranial procedures. The aim of this retrospective analysis is to describe the principles on which the technique of endoscope-assisted brain surgery is based, to give an impression of possible indications for endoscope-assisted microsurgical procedures, and, with illustrative cases, to delineate the advantages of endoscopes used as surgical instruments during microsurgical approaches to intracranial lesions.

CLINICAL MATERIAL AND METHODS

During a period of 4.5 years, 402 microsurgical intracranial procedures and procedures at the craniocervical junction were performed as endoscope-assisted microneurosurgical operations. The data of 380 patients were available for retrospective analysis (Table 1). The age range of the patients was 3 months to 76 years, with a mean of 33 years. There were 182 female and 198 male patients.



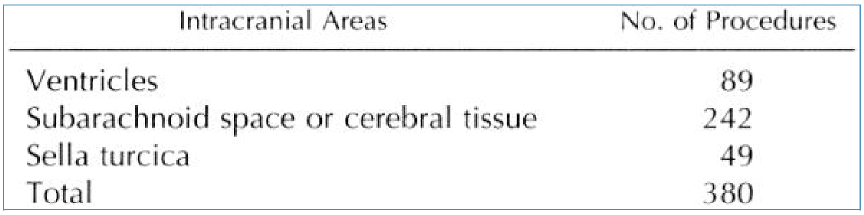
Intracranial Lesions	No. of Procedures
Tumors	205
Cerebral aneurysms	53
Cysts	86
Neurovascular compression syndromes	36
Total	380

TABLE 1. Lesions Treated with Endoscope-assisted Microsurgery

All procedures were planned as common microsurgical operations with tailored craniotomies or craniectomies, so that, if necessary, each of the operations could have been performed or completed without the use of endoscopes. During the course of each operation, one or more endoscopes were used as surgical instruments according to the guidelines presented in"Endoscope-assisted Brain Surgery: Part 1-Evolution, basic concept, and current technique" (16a).

RESULTS

The lesions treated with videoendoscope-assisted microsurgery comprised 205 tumors, 53 cerebral aneurysms, 86 cysts, and 36 neurovascular compression syndromes (Table 1). To improve the visualization of the operating field around these lesions without further retraction or dura and bone resection, the endoscopes were used in the ventricular system in 89 cases, in the subarachnoid space or in the cerebral tissue in 242 cases, and in the sella in 49 cases (Table 2).



Intracranial Areas	No. of Procedures
Ventricles	89
Subarachnoid space or cerebral tissue	242
Sella turcica	49
Total	380

TABLE 2. Intracranial Areas Approached by Endoscope-assisted Microsurgery

The videoendoscopy system was easy to integrate into the standard microsurgical system because the endoscopes were safely fixed to the Mayfield headholder, thus allowing the neurosurgeon to perform the procedures with both hands. Frequently, the picture-in-picture mode for the endoscopic and microscopic channels on one monitor screen was useful to determine the exact intracranial position of the endoscope. Although not of major importance, the estimated reduction of operation time achieved by the intraoperative use of endoscopes was from 10 minutes to approximately 2 hours, mainly depending on the extent of unopened dura and unresected bone.

There were no intraoperative complications caused by the use of the endoscopes. In addition, the number of postoperative complications after endoscope-assisted microneurosurgical procedures was not higher than with previous routine microsurgery. There were three cases of postoperative meningitis requiring intravenous application of antibiotics (0.8% of this series), four cases of cerebrospinal fluid leakage requiring treatment with lumbar cerebrospinal fluid drainage (1.0% of this series), and four cases of postoperative hemorrhage (1.0% of this series). Two were intraventricular hemorrhages, and two were subdural hemorrhages. Two of the hemorrhages required subsequent surgery with hematoma evacuation and temporary ventricular drainage. To demonstrate the particular benefit of endoscope instrumentation during open microsurgery, we present two illustrative case reports.

Illustrative Case 1

This 58-year-old man had a 15-month history of episodic ataxia, left-sided tinnitus, and headache. Magnetic resonance imaging revealed a cavernous malformation and a small hemorrhage of the left lower ventrolateral pons, just cephalad to the pontomedullary sulcus (Fig. 1). Surgical resection was recommended because of the accessibility of the lesion, its symptomatic nature, including hemorrhage, and the patient's age.

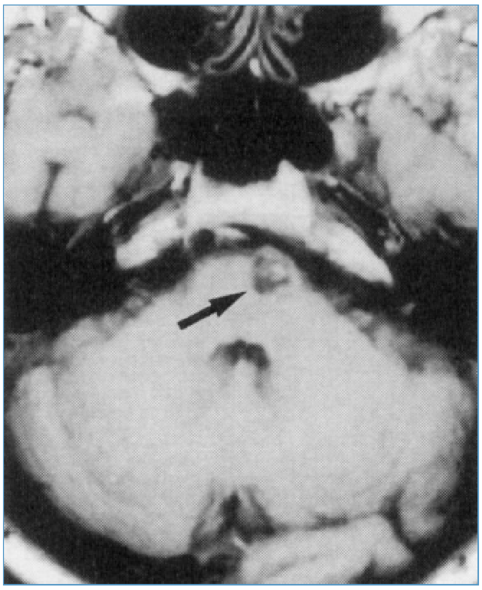
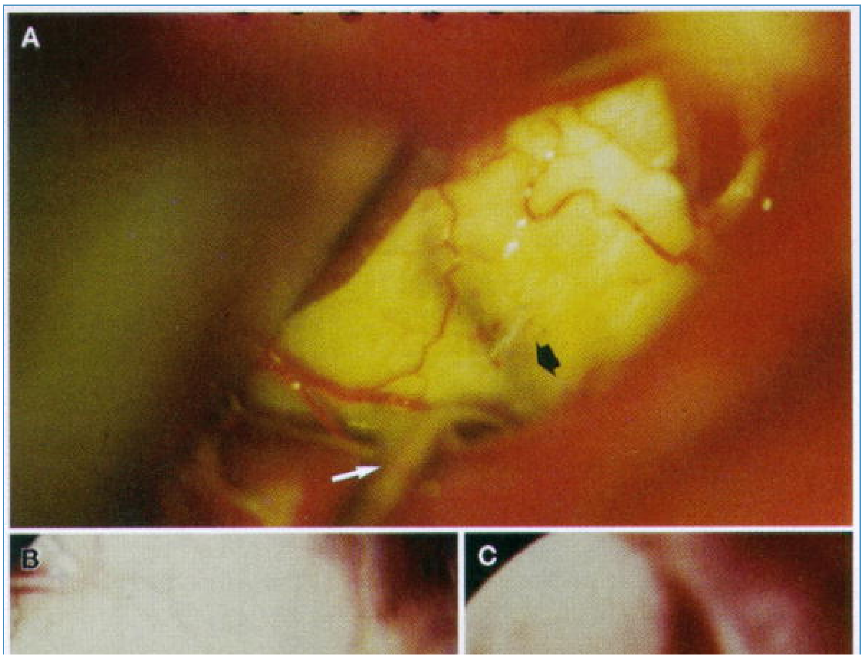


FIGURE 1. T1-weighted magnetic resonance image in the axial plane, demonstrating the lesion (*arrow*), suspected to be a cavernoma, on the left side of the pons. The pontine lesion seems to be completely covered by nervous tissue.

A left retromastoid craniotomy with exposure of the sigmoid sinus was performed. The dura was opened just behind the sigmoid sinus, and, using slight retraction of the cerebellum, the lateral surface of the pons was approached. Through the operating microscope, a yellowish surface of the pons and residues of a small hemorrhage in the tissue of the pons could be detected (Fig. 2A).



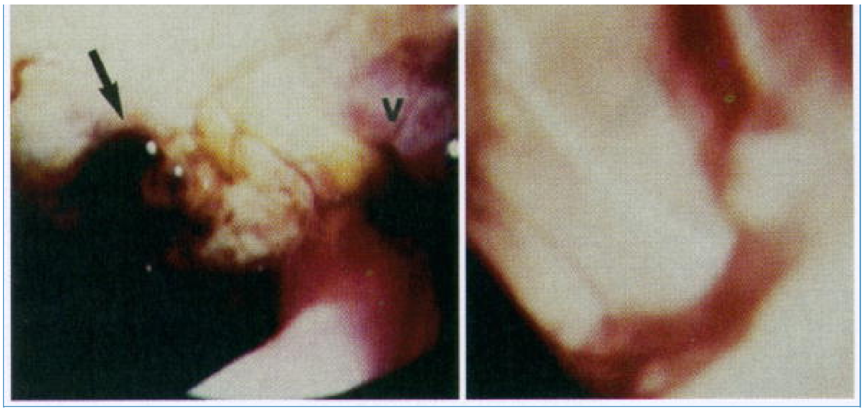


FIGURE 2. *A*, view through the operating microscope to the caudal part of the left side of the pons after left retromastoid craniotomy. Note the yellowish surface of the pons, indicating former hemorrhage, and the grayish area (*dark arrow*), indicating the position of the cavernoma underneath an intact layer of nervous substance. While introducing the "viewing dissector" (curved, rigid fiberscope manufactured by Aesculap), the position of its shaft (*white arrow*) can be safely controlled through the operating microscope.*B*, aspect of the more ventral surface of the left pons, as seen through the "viewing dissector," which was introduced under microscopic control. Note the dark area (*arrow*) where the cavernoma reaches the surface of the pons. Thus, using intraoperative endoscopy, it was possible to determine the least harmful entry into the pontine substance without applying retraction to the cerebellum, without further removal of the mastoid process or petrous bone, and without further opening of the dura. Note the draining vein (*v*) of the cavernoma emerging from the pons. *C*, view through a 30-degree lens scope introduced into the cavity within the pons left behind after careful removal of the cavernoma. Only with the help of the endoscope was precise control of the completeness of resection of the cavernoma possible, which is important for the prognosis of the patient.

At this point in time, the search for an ideal way of entrance into the pons substance to remove the cavernoma would have meant to further drill off the mastoid, to widen the dura opening, and to mobilize the sigmoid sinus. The use of a viewing dissector (curved, rigid fiberscope) (Aesculap AG, Tuttlingen, Germany) rapidly and accurately depicted the best area for opening the ventrolateral surface of the pons to approach the cavernoma (Fig. 2B). Thus, the endoscope was useful to limit the size of the craniotomy and to select the adequate area for incision of this sensitive part of the brain stem. After excision of the lesion under endoscopic observation with a 30-degree lens scope, this scope was carefully introduced into the existing cavity within the pons to control the completeness of resection (Fig. 2C), thus providing the surgeon with important information about the prognosis of the patient. This maneuver was achieved without any retraction of the adjacent tissue of the pons.

The operation lasted 3 hours 15 minutes, and the estimated time saved by the intraoperative use of endoscopes during this procedure was approximately 45 to 60 minutes. The patient was discharged to a rehabilitation service on the 14th postoperative day in good condition except for a mild right-sided hemiparesis. He recovered completely within 2 months after the operation.

Illustrative Case 2

This 49-year-old man had a 2-year history of progressive left-sided hypacusis, episodic tinnitus, vertigo, and vomiting. Magnetic resonance imaging revealed a right megadolichovertebral artery transversing and compressing the medulla oblongata caudal to the oliva, extending into the left cerebellopontine angle, and causing neurovascular compression of the VIIth and VIIIth cranial nerves in the dorsolateral pontomedullary sulcus on the left side where the conjunction of the right megadolichovertebral artery with the left megavertebral artery was supposed (Fig. 3A). Cerebral angiography disclosed that this contention was correct. The contrast injection of the right vertebral artery demonstrated this artery to fill the vertebral conjunction, which was dislocated to the left side and cephalad. The megadolichobasilar artery was shown to cross the ventral aspect of the pons from left to right in a horizontal fashion (Fig. 3B).

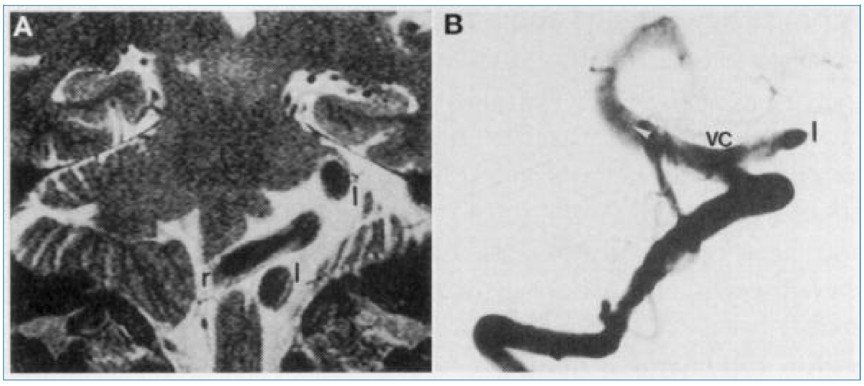


FIGURE 3. *A*, T2-weighted magnetic resonance image in the coronal plane, demonstrating the right megadolichovertebral artery transversing and compressing the medulla oblongata (*r*). Note the two sections through the left megavertebral artery (*l*). *B*, angiogram, left oblique view, after contrast injection into the right megadolichovertebral artery. Note the contrast filling of the vertebral conjunction (*vc*), some retrograde flow in the distal portion of the left vertebral artery(*l*), and contrast filling of the megadolichobasilar artery(*white arrowhead*), which is crossing over the pons back to the right side.

Vascular decompression of the left vestibulocochlear nerve and the medulla oblongata was recommended because of progressing neurological symptoms in combination with an impairment of life quality caused by the vertigo and vomiting. A left retromastoid craniotomy was performed. After opening the dura and dissecting the premedullary cisterns, two large arterial loops were identified, one being the left megavertebral artery and the other being the right megadolichovertebral artery. In addition, the 9th, 10th, and 11th nerves converging to the jugular foramen as well as the hypoglossal nerve were exposed (Fig. 4A). However, under the operating microscope, it would not have been possible to observe the vascular compression of the seventh and eighth nerves without retraction of both vertebral artery loops, because these vessels extremely obscured the visual field of the microscope.

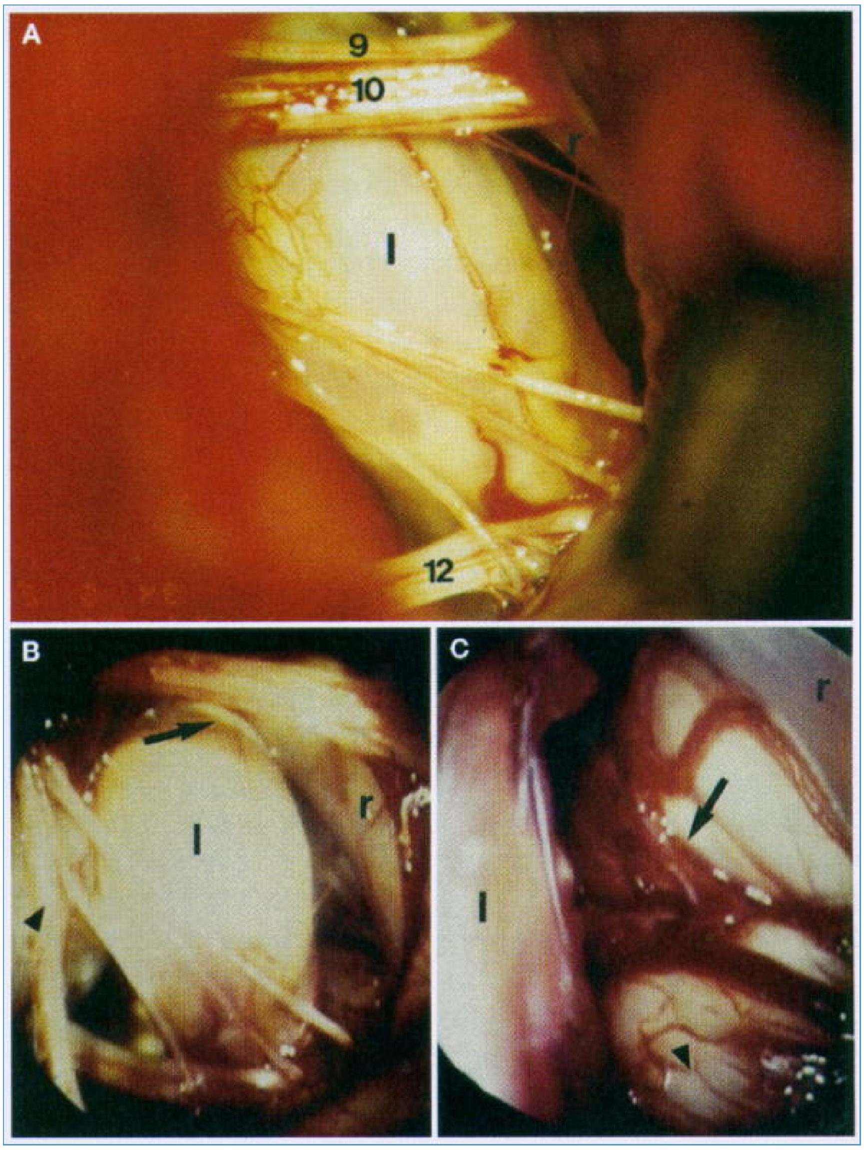


FIGURE 4. *A*, view through the operating microscope after left-sided retromastoid craniotomy. Although the loop of the left vertebral artery (*l*) and a part of the right vertebral artery(*r*) as well as Cranial Nerves IX, X, XI, and XII can be readily seen, both vertebral arteries obscure the view to the compressed eighth nerve. To dissect the eighth nerve running more rostrally, it would have been necessary to extend the craniotomy or to retract the vertebral arteries.*B*, view through a 4.2-mm lens scope, which was introduced under microscopic observation. Without extending the craniotomy and without retracting the vertebral artery loops, the compression of the eighth cranial nerve, which turns out to be impinged between the left (*l*) and right (*r*) vertebral arteries close to the vertebral conjunction, can be clearly seen (*arrow*). Compared to the microscopic view, the endoscopic aspect reveals more details of the operating field (e.g., one more root of the accessory nerve) [*arrowhead*], the entrance of the hypoglossal nerve into the hypoglossal canal, and the ventral aspect of the right vertebral artery). *C*, view through a 4.2-mm lens scope. The scope has been advanced between the left and right vertebral arteries. Note the ventral wall of the right vertebral artery (*r*) and the dorsal wall of the left vertebral artery (*l*). The right vertebral artery has been mobilized carefully from the brain stem, and a bluish area where neurovascular compression was evident can be seen on the lateral medulla oblongata (*arrowhead*). Because there were some rather short brain stem perforators (*arrow*) emerging from the left vertebral artery only, this artery was not mobilized to avoid affecting blood flow in the medulla oblongata.

Using a 4.2-mm lens scope, which was introduced into the perimedullary cistern without retraction of any vascular or nervous structures, it was easily possible to demonstrate the seventh and eighth nerves to be compressed by an impingement between both left and right megavertebral arteries (Fig. 4B). Further advancement of the endoscope between both vertebral artery loops clearly depicted several rather short perforators to the medulla oblongata emerging only from the left vertebral artery and a neurovascular compression of the brain stem only by the right vertebral artery (Fig. 4C). Thus, the decision was made to interpose only two free autologous muscle pieces (one between the left vertebral artery and the seventh and eighth nerves and one between the brain stem and the right vertebral artery) so as not to affect the short perforators to the brain stem.

The intraoperative use of an endoscope in this procedure was especially helpful to safely identify the pathological anatomy without retraction of vessels or cranial nerves. This would not have been feasible with the routinely used operating microscope alone. The entire operation lasted 2 hours 20 minutes. The estimated time saved by the intraoperative use of the endoscope in this procedure was approximately 30 to 45 minutes.

The patient experienced immediate, complete, persisting relief from vertigo and vomiting and partial relief from tinnitus. The patient was discharged home on the 8th postoperative day in excellent condition.

DISCUSSION

Benefit of endoscope-assisted microneurosurgery

These illustrative case reports of a total series of 380 analyzed procedures demonstrate that endoscope-assisted microsurgery was advantageous to reduce the size and the operation-related tissue trauma of approaches to lesions in the ventricular system, brain tissue, and subarachnoid space. Although applying less retraction during tumor removal, the visual control of parasellar, endosellar, and even retroclival structures during tumor resection was improved. The endoscope-assisted microsurgical treatment of intraventricular tumors and cysts offered better control of the back side and of the lateral margin of these lesions. However, the intraventricular and the subarachnoidal use of endoscopes requires an endoscope-adapted knowledge of neuroanatomy, as stressed by several authors (4,6-8,11,13,15-17,19). As compared with endoscopic treatment alone (4), endoscope-assisted microsurgical fenestration of arachnoid cysts offered the opportunity to use common microsurgical instruments and to control all steps of the fenestration, because the ipsilateral as well as the contralateral wall of the cysts could be visualized simultaneously.

Endoscope instrumentation was also helpful during procedures in the posterior cranial fossa and at the craniocervical junction. It allowed for inspection of channels and hidden structures (e.g., the internal auditory meatus, the ventral surface of the brain stem, the ventral aspect of root entry zones of cranial nerves, the content of the foramen magnum, and the upper cervical canal), both without retraction and without resection of dura and bone edges.

Endoscope instrumentation during surgery for cerebral aneurysms was useful to dissect perforators on the back side of the aneurysms, to identify important vessel segments without retraction of the aneurysms and the arteries, to help in the decision whether to treat large or giant aneurysms with clips or with wrapping material, and to control the completeness of aneurysm clipping. Especially in deep-seated aneurysms of the posterior circulation, the clipping procedure itself can be performed under simultaneous microscopic and endoscopic control using the anatomic windows between the structures. For example, the clip and the clip applier used for the closure of a basilar tip aneurysm can be advanced under microscopic control through the retrocarotid window while the endoscope is positioned in the optocarotid window.

Aspects of safety and minimization of operation-related trauma

On the one hand, technical methodologies and their adequate application in today's neurosurgery have become more complex (5). This holds true also for the endoscope-assisted brain surgery described in this report. On the other hand, during the past decades, the consideration of safety aspects and of trauma minimization during neurosurgical operations has constantly gained more importance, from the medical, legal, and technological points of view. Recently, it was shown that the surgical resection of third ventricle colloid cysts with a steerable fiberscope required less operating time and less postoperative recovery time than with conventional transcallosal microsurgical resection. In addition, postoperative complications after endoscopic resection were less frequent than those after transcallosal microsurgical procedures (13). Nevertheless, the precise control of the position of the endoscope within the operating field is an enormous safety factor. Various techniques, such as real-time ultrasonography (2,21), frame-based and frameless stereotaxy (8,9,12), and robotics (3), have been used to achieve precision in endoscope positioning. Although all these techniques can be used for endoscopy with rigid lens scopes, they require additional technical equipment and, thus, may add inherent methodological errors, which decrease the safety for the patient. During endoscope-assisted microsurgical procedures, these problems do not occur. The intracranial position of the endoscope shaft can be controlled by the routinely used operating microscope at all steps of the operation. In addition, with this microsurgical technique, the endoscopes have the function of special surgical instruments helping to increase the visual field of the operating microscope and the light intensity within the surgical field.

CONCLUSION

Without the intraoperative use of endoscopes, the aim of looking into hidden but important corners of the operating field can be accomplished only by retraction of neuronal or vascular structures and/or by resection of dura and bone edges. In this regard, videoendoscope-assisted microsurgery, as described here, is a new microsurgical technique using the endoscopes as surgical instruments under microscopic control. This technique is easy to learn for trained neurosurgeons, and the endoscopes fixed to the headholder can be integrated into the standard microsurgical system without difficulty. Although the results of the consecutive series reported herein cannot be directly compared to such results achieved with microsurgery alone, endoscope-assisted brain surgery can be recommended as a time-saving, trauma-reducing procedure that is likely to improve postoperative outcomes.

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Key words: Cerebral aneurysm; Endoscopy; Intracranial cyst; Intracranial tumor; Microsurgery; Neurovascular compression

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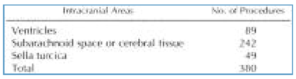
☐ Table 1



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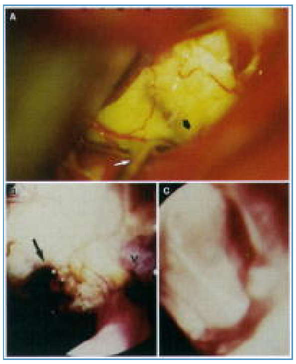
☐ Table 2

☐ Figure 1



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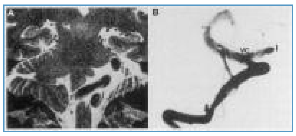

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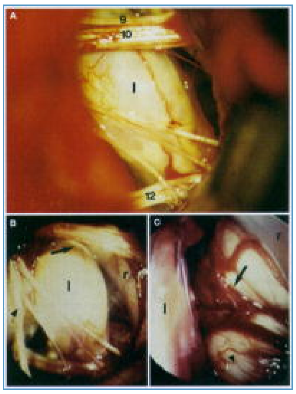

☐ Figure 4

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