



NEUROENDOSCOPY

10

Charles Teo and Ralph Mobbs

INTRODUCTION

Neuroendoscopy is defined as the discipline of applying an endoscope to the treatment of conditions of the central nervous system. There have been four major stages in the development of neuroendoscopy.

The pioneering stage of neuroendoscopy started almost a century ago when the urologist L'Espinasse performed the first endoscopic procedure on the brain (in 1910).¹ He attempted endoscopic coagulation of the choroid plexus to treat a hydrocephalic patient. The next epoch of neuroendoscopy came in the 1920s and 1930s when Dandy and Mixter attempted endoscopic fenestration of the third ventricle for the treatment of hydrocephalus.²

The third significant leap in neuroendoscopy came in the early 1970s. Technological advances in optics and electronics allowed the development of both flexible fiber and high-resolution rigid endoscopes that were used successfully for operating within the ventricles.

The current stage of neuroendoscopy has been the explosion of endoscopic third ventriculostomy for the treatment of hydrocephalus and endoscope-assisted minimally invasive surgical procedures which began in the 1980s and 1990s, and continue to this day.

Initially, endoscopic procedures were confined to the ventricles of the brain, which contain the ideal medium: a crystal-clear fluid. However, the endoscope is now used in treating a wide spectrum of neurosurgical pathology, and the indications for neuroendoscopy are rapidly expanding. Neuroendoscopy follows a general trend in neurosurgery of treating disease with minimally invasive techniques to reduce approach-related trauma and to improve visualization of the pathology. In an attempt to minimize operative trauma, the surgeon endeavors to limit the size of the exposure and to avoid unnecessary brain retraction, which can cause damage by increasing local cerebral tissue pressure and decreasing regional cerebral blood flow.³ This surgery-related trauma may compromise the neurologic outcome after micro-neurosurgical procedures, a factor that is potentially minimized with the use of neuroendoscopy techniques.

The endoscope enhances the surgeon's view by increasing illumination and magnification.^{4,5} Endoscopic tumor removal or cerebrospinal fluid (CSF) diversion through endoscopic fenestration may allow patients to undergo a less morbid procedure or to avoid shunt placement. In addition to benefiting the patient, the endoscope is an excellent teaching tool. The anatomical definition and unique angles of view available with the endoscope help

trainee residents to have a better understanding of operations by illuminating anatomico-pathological structures. A comparison of the various magnification modalities is presented following a survey of neurosurgeons (Table 10.1).

We will discuss the applications of endoscopy to intracranial surgery under the following headings:

- equipment;
- endoscopic third ventriculostomy;
- simplification of complex hydrocephalus and intracranial cysts;
- endoscopic applications to neuro-oncology;
- endoscope-assisted microsurgery;
- endoscopic transsphenoidal surgery;
- microvascular decompression;
- miscellaneous applications;
- complications of neuroendoscopy.

EQUIPMENT

It is paramount that the surgeon has a dedicated neuroendoscopy set-up to achieve optimal surgical outcomes. In addition, it is essential to have recording equipment that captures images on video or digital format for later study. The endoscopy tower should include: video camera, camera control units, light source, video recorder, video monitor and a computerized system for storage of video segments or single-picture capture. Endoscope positioning and fixation arms capable of being fastened to the operating table or headrest help the surgeon to avoid arm fatigue, which can disturb eye-hand coordination. Endoscopic instruments include a pair of grabbing forceps and scissors, a coagulation device (either monopolar or bipolar), an irrigation system, and a straight and 30°-angled scope (Figures 10.1, 10.2). In addition, a knowledgeable assistant is essential so that the surgeon can work two-handed (Figure 10.1).

Frameless computerized neuronavigation has been increasingly used in intracranial endoscopic neurosurgery and has proven to be accurate, reliable, and useful in selected intracranial neuroendoscopic procedures to improve the accuracy of the endoscopic approach.⁶

ENDOSCOPIC THIRD VENTRICULOSTOMY

The first attempted endoscopic third ventriculostomy (ETV) was undertaken in 1923.⁷ During the investigative period in the

Table 10.1 Comparison of loupe, microscope and endoscope for neurosurgical procedures

	Loupe	Microscope	Endoscope
Cost	Minimal	Moderate	Moderate
Magnification	Fixed	Variable	Variable
Illumination	With headlight	Superior	Superior
Time to setup	NA	Minimal	Minimal
Scrub staff familiarity	NA	Acceptable	Acceptable
Incision/exposure	Variable	Variable/minimal	Minimal
Surgeon fatigue	Neck, Eye	Eye	Arm
Look around corners?	No	No	Yes (30°, 70°, 110°)
Teaching tool	Poor	Excellent	Excellent
Depth of view	3D	3D	2D (3D possible)

NA, not applicable; 2D, two-dimensional; 3D, three-dimensional.



Figure 10.1 An assistant is paramount for successful endoscopy. Note the positioning of the monitor for surgeon comfort.

subsequent decade, the endoscopic technique was restricted by inferior illumination, magnification, and surgical morbidity. The endoscopes were not specifically designed for use within the brain. Technological advances in the 1970s and 1980s produced the much needed improvements in endoscopic instrumentation. Thus, the ETV technique was “rediscovered” in the 1970s and 1980s.⁸ There are numerous studies now confirming the high success rate and low complication rate of ETV. It is now considered a safe and effective treatment for obstructive hydrocephalus in selected patients.^{9,10} In addition, ETV has numerous potential benefits over the standard shunt procedure, which possesses its own set of inherent risks and complications, including (but not limited to) infection, slit ventricle syndrome, and mechanical malfunction.

Indications for performing ETV are based on computed tomography or magnetic resonance imaging (MRI) findings that demon-



Figure 10.2 The essentials of endoscopy; endoscope, light source, camera and irrigator for intraventricular surgery.

strate a noncommunicating-type hydrocephalus with obstruction at the level of, or distal to, the posterior third ventricle. Patients with hydrocephalus from aqueductal stenosis are, in general, excellent candidates for ETV. Although controversial,¹¹ patients less than 6 months of age have not enjoyed uniformly good results with ETV, and most authors do not advocate the procedure in this group.

ETV has a role in the treatment of hydrocephalus secondary to posterior fossa tumors and is being used for that application in many centers. Neuroendoscopy is being used successfully in pineal tumors simultaneously to treat the associated hydrocephalus by ETV and to biopsy by endoscopy the tumor for diagnosis.¹²

A brief description of ETV is as follows.

Step 1: Patient positioning. The patient is positioned supine with the head slightly flexed. Note the approach angle made by the endoscope (Figure 10.3).

- Step 2:** Burr hole. A coronal burr hole is performed with the optimal entry position at 3 cm lateral to the midline and 1 cm anterior to the coronal suture¹³ (Figure 10.4).
- Step 3:** Entry into the lateral ventricle. The endoscope is advanced into the lateral ventricle with or without stereotactic assistance, depending on surgeon preference.
- Step 4:** Entry into the third ventricle. Under direct vision, the endoscope is passed through the foramen of Monro into

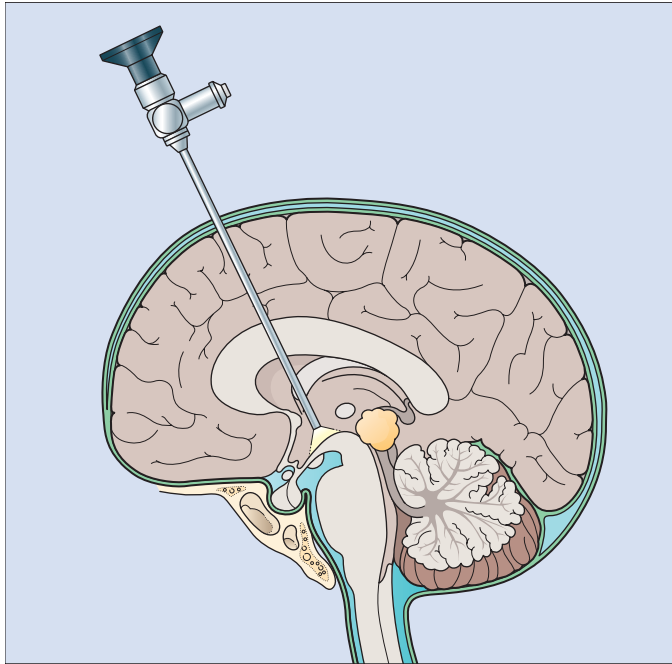


Figure 10.3 The approach angle made by the endoscope for endoscopic third ventriculostomy.

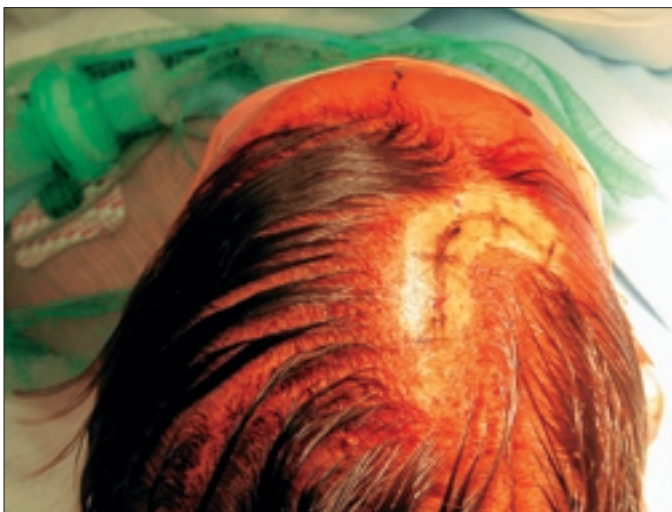


Figure 10.4 An incision is made so that the burr hole is 3 cm lateral to the midline on the right-hand side. A curved incision is prepared so that a shunt/reservoir can be inserted if endoscopic third ventriculostomy is unsuccessful.

the third ventricle. Note that the foramen of Monro can be identified by the thalamostriate vein and choroid plexus (Figure 10.5). The third ventricle is inspected prior to perforation of the floor.

- Step 5:** Ventriculostomy. The ventriculostomy is placed just posterior to the infundibular recess of the pituitary stalk, anterior to the mamillary bodies. Perforation is either blunt, using the endoscope, or with an instrument followed by balloon catheter dilatation (Figures 10.6–10.8).
- Step 6:** Inspection and hemostasis. Entry into the prepontine cistern is performed with caution so as to avoid injury to the basilar apex and perforating vessels. Hemostasis with irrigation is achieved until a clear operative field is visualized (Figure 10.9).

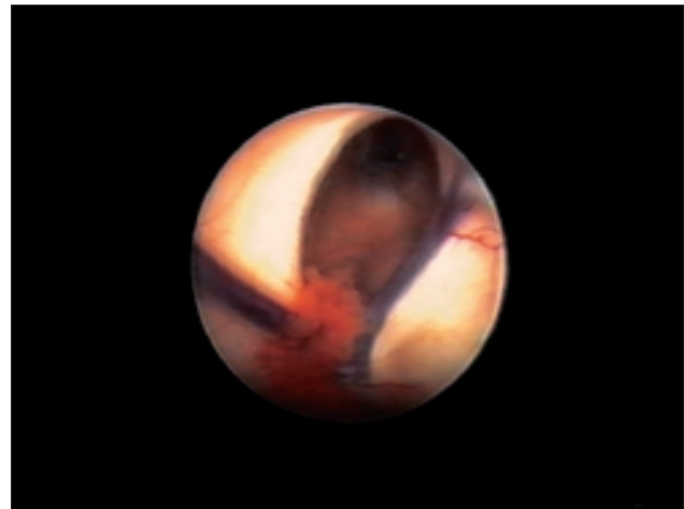


Figure 10.5 The anatomy of the foramen of Monro is helpful to guide the operator from the lateral ventricle into the third ventricle.

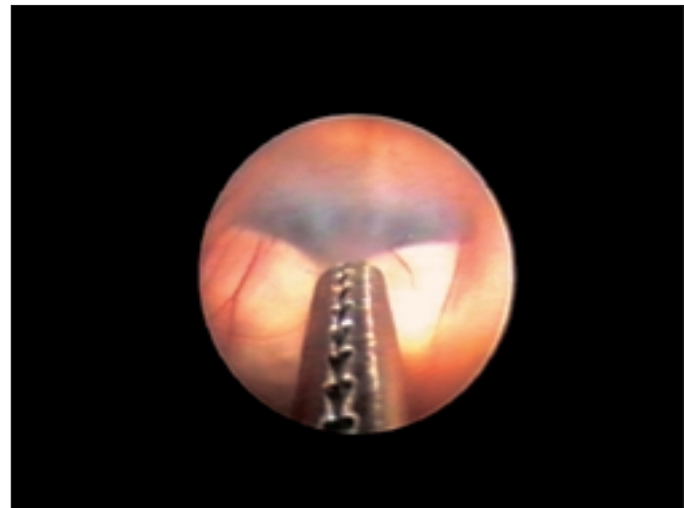


Figure 10.6 A blunt instrument is used to perforate the floor anterior to the mamillary bodies.

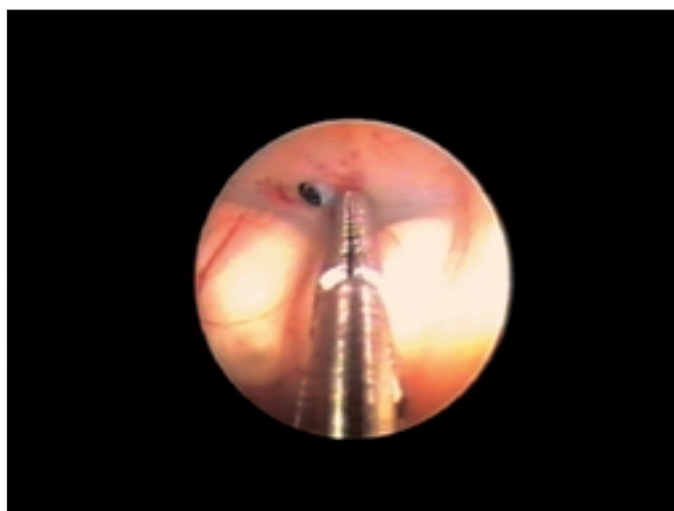


Figure 10.7 The initial fenestration made by the blunt forceps.

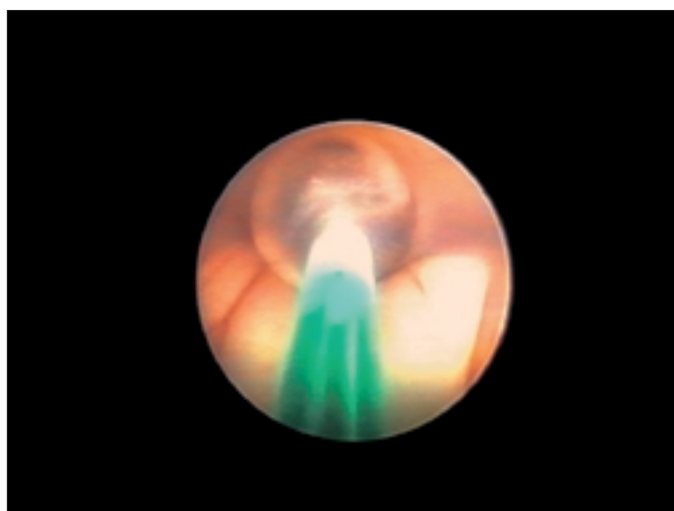


Figure 10.8 The initial fenestration is enlarged with a balloon.

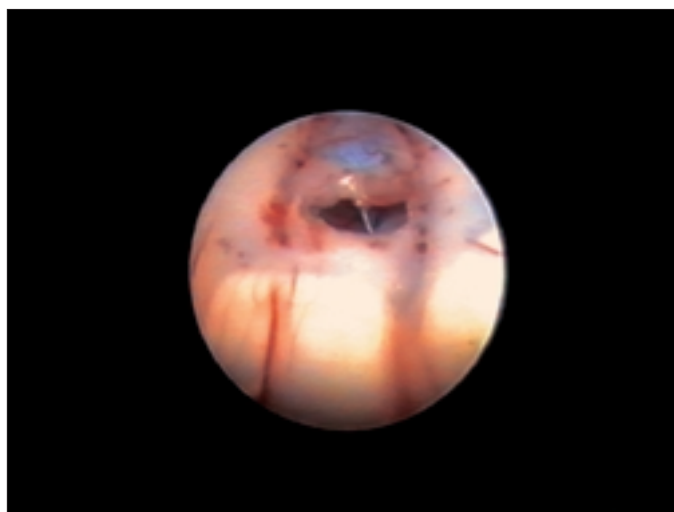


Figure 10.9 The fenestration is complete.

There are several precautions when performing ETV. The anatomy may be altered by tumors, such as a brainstem glioma. This may distort the floor of the third ventricle and displace the basilar artery forward so that the safe zone to penetrate the floor is limited.

Hydrocephalus resulting from tumor obstruction may be relatively acute in onset, with the floor of the third ventricle appearing opaque and non-attenuated. Penetration will be difficult and invariably requires a sharper technique without visualization of the underlying neurovascular structures, which increases the risk.

Also, patients who have been previously shunted are technically more difficult to perform ETV upon, as they have less marked ventricular dilatation, a thicker ventricular floor (Figure 10.10), and often abnormal anatomy. In some patients, an ETV procedure may have to be abandoned if the floor of the third ventricle is too thick, blood is obstructing the endoscopic view, or the basilar artery is sitting directly under or too close to the proposed site of fenestration.

Nevertheless, ETV has an overall success rate of approximately 75% after 3 years but depends on patient selection and the experience of the surgeon. The results of ETV compare favorably with those obtained after shunting, especially in patients with posterior fossa tumors.¹⁴ In addition, ETV would appear to represent an economic advantage over shunting.¹⁵ Table 10.2 outlines some of the studies that have investigated the results of ETV. However, no large multicenter randomized studies have been performed to compare the two modalities in a meaningful manner.

Failure of ETV can occur early or late. Early failure is the result of factors including bleeding around the fenestration site, unnoticed additional arachnoid membranes occluding the flow of CSF, and an inadequate size of the fenestration. Late failure is the

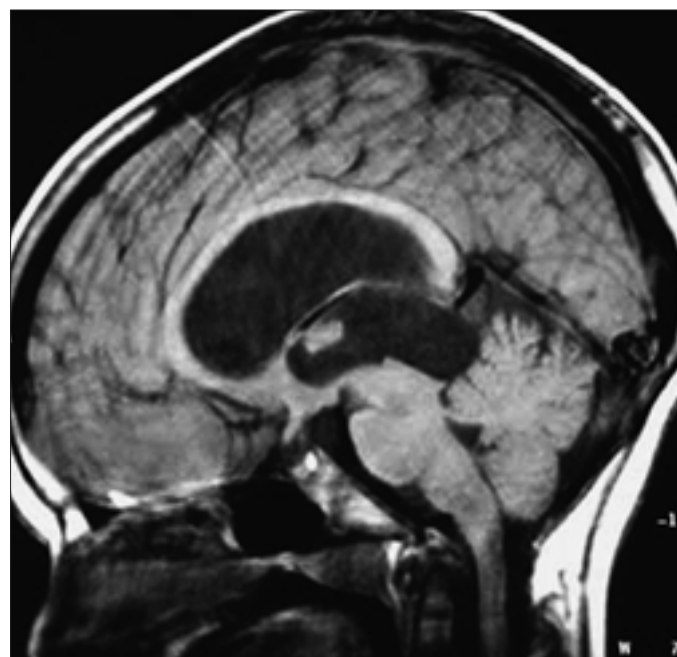


Figure 10.10 A thick third ventricular floor can make endoscopic third ventriculostomy difficult or impossible. Close inspection of the midsagittal magnetic resonance image is important prior to endoscopic third ventriculostomy.

Table 10.2 Results of endoscopic third ventriculostomy for treatment of hydrocephalus

Ref.	<i>n</i>	No. of patients with aqueductal stenosis	Etiology other than aqueductal stenosis	Success rate (%)	Follow-up (months)
Dalrymple and Kelly ⁴⁰	85	24	61	87	1–66
Jones <i>et al.</i> ⁴¹	103	NA	NA	61	NA
Choi <i>et al.</i> ⁴²	81	39	42	91	NA
Hopf <i>et al.</i> ⁹	98	40	58	76	26
Cinalli <i>et al.</i> ¹¹	213	126	87	72	45.5
Gangemi <i>et al.</i> ⁴³	125	77	48	86	NA
Fukuhara <i>et al.</i> ⁴⁴	89	34	55	67	3–62.8

n, number of patients; NA, not available or stated in paper.

result of subsequent closure of the fenestration by gliotic tissue or arachnoid membrane. This problem is potentially serious. There are now several reports in the literature of death following late failure of ETV¹⁶ and this remains a management problem because the failure can occur in a short period of time and may be unpredictable. Tumor progression and inadequate CSF absorption at the level of the arachnoid villi may result in early or late failure. It is not understood why a cohort of patients with open fenestrations exhibits deterioration after months of well-being.¹⁷

Clinical review is the best assessor of outcome. The significance of postoperative ventricular size remains a controversial point because some patients have persistent ventriculomegaly despite lower intracranial pressure and marked clinical improvement.

Procedure-related complications reported in the literature include bradycardia, hypothalamic dysfunction and hemorrhage from damage to arteries, ependymal veins, or the choroid plexus. The complications fall into two main categories; short-term complications, which are largely intraoperative and technique-related, and long-term complications which occur at a much lower rate.¹⁸ Blunt perforation is less likely to damage vascular structures below the floor, however traction on the lateral walls of the third ventricle, which is associated with blunt manipulation, is thought to account for the transient hypothalamic complications.¹⁹ Those who advocate sharp perforation report less bleeding from the operative site but risk vascular perforation of deeper vessels such as the basilar artery or its perforators. In addition, there have been reports of frontal lobe infarction, subdural hematoma, pseudoaneurysm formation, epilepsy, pneumoencephalus, syndrome of inappropriate antidiuretic hormone secretion (SIADH), third-nerve palsy and fatal subarachnoid hemorrhage. However, in experienced hands these complications are quite rare.

SIMPLIFICATIONS OF COMPLEX HYDROCEPHALUS AND INTRACRANIAL CYSTS

Patients with shunt infections or intraventricular hemorrhage of prematurity can suffer from compartmentalization of the ventricles often requiring multiple shunt placements. Multiple shunts are not ideal, and are associated with high failure rates and subsequent infections. Endoscopy offers a simple means of

communicating isolated CSF spaces and ventricles by membrane fenestration. This can be done through the same burr hole as that for the placement of a ventricular catheter. Fenestration of the septum pellucidum to connect the two lateral ventricles in patients with loculated ventricles will preclude the need for two shunts in the majority of patients.

Many types of cysts can exist within the ventricular system. Arachnoid cysts, although typically extra-axial, can present within the ventricles, as well as choroid plexus cysts, neoplastic cysts and infected cysts (e.g. hydatid and cystercercotic cysts). In many patients, arachnoid cysts can be either endoscopically resected or fenestrated to achieve a successful outcome.

The rapid advances in endoscopic technology have made this the surgical approach of choice for the treatment of most intracranial cysts at our institution. In the preliminary series reported by Walker *et al.*,²⁰ nine of 14 children (64%) with arachnoid cysts were successfully treated by endoscopic fenestration through a burr hole, thereby avoiding the need for craniotomy. Even cysts confined to the pituitary fossa are ideally suited to endoscopic transsphenoidal surgery. Ventriculo-cysto-cisternostomy offers long-term decompression of suprasellar arachnoid cysts without the need for shunting (Figure 10.11). The senior author has had success in fenestrating arachnoid cysts, cysts of the cavum velum interpositum, neuroepithelial cysts of the ventricle, colloid cysts and large pineal region cysts. In cases where the ventricles are small, frameless stereotactic guidance has been useful in planning the burr hole placement and trajectory to these cysts. The goal of surgery for arachnoid cysts is symptomatic improvement. This is particularly pertinent with endoscopic fenestration, as the appearance of the cyst on postoperative imaging may be only slightly diminished, despite marked clinical improvement.

ENDOSCOPIC APPLICATIONS TO NEURO-ONCOLOGY

Neuro-oncology provides an ideal venue for the application of endoscopy. The advantages of improved visualization of intraventricular pathology, refined management of tumor-related hydrocephalus, safer biopsies, and minimally invasive removal of intraventricular tumors are invaluable supplements to traditional tumor management. Endoscopy is the next step for surpassing the

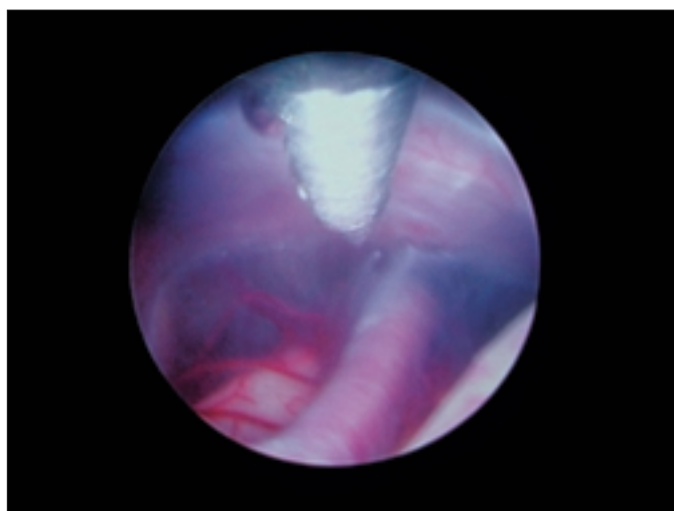


Figure 10.11 Fenestration of a suprasellar cyst: third ventriculostomy is initially performed to gain access to the cyst. Note the basilar artery and cyst wall.

limitations of traditional microsurgery and allows the neurosurgeon to view tumor remnants such as those hidden behind eloquent brain tissue, a cranial nerve, or the tentorial edge. Once a tumor is removed, the surgeon can use the endoscope to assess the degree of resection. Often, the same surgery can be carried out through a smaller craniotomy by using the endoscope, in keeping with the concept of minimally invasive, yet maximally effective, surgery.²¹ By allowing a more complete removal, endoscopy may improve the survival rates for patients with benign tumors.^{22,23} Adjunctive procedures, such as third ventriculostomy and septostomy, can be performed through the same access to manage related problems such as secondary hydrocephalus. Endoscopic tumor removal or CSF diversion may allow patients to avoid shunt placement.

There are very few articles in the neurosurgical literature on the application of endoscopy for the removal of intraventricular tumors. Most of the endoscopic experience has been obtained in the removal of colloid cysts.²⁴⁻²⁶ Examples of lesions that may be approached with the endoscope include colloid cysts (Figures 10.12, 10.13), subependymal giant cell astrocytomas, gliomas, subependymomas, and choroid plexus cysts.²⁷ Most of these lesions are relatively avascular and as a result are amenable to endoscopic treatment. Patients with colloid cysts are appropriate candidates for endoscopic excision at some institutions. The results with these tumors are often good in experienced hands; however, the long-term results in terms of recurrence are not yet available. The burr hole is made so that the scope enters the ventricle as far from the tumor as possible and so that the scope is directly viewing the tumor, not peering from around a corner. The distal approach allows the surgeon to orient himself by identifying normal anatomical structures before encountering the abnormal anatomy. As most of the distal part of the scope is within the ventricle, it also allows the surgeon to move the scope in multiple directions more freely without damaging the surrounding normal brain.

Not all intraventricular tumors should be approached endoscopically. The ideal tumor for endoscopic consideration has the following characteristics:



Figure 10.12 Endoscopic techniques are ideal for colloid cyst removal. Coronal magnetic resonance image demonstrating enhancement of a colloid cyst.

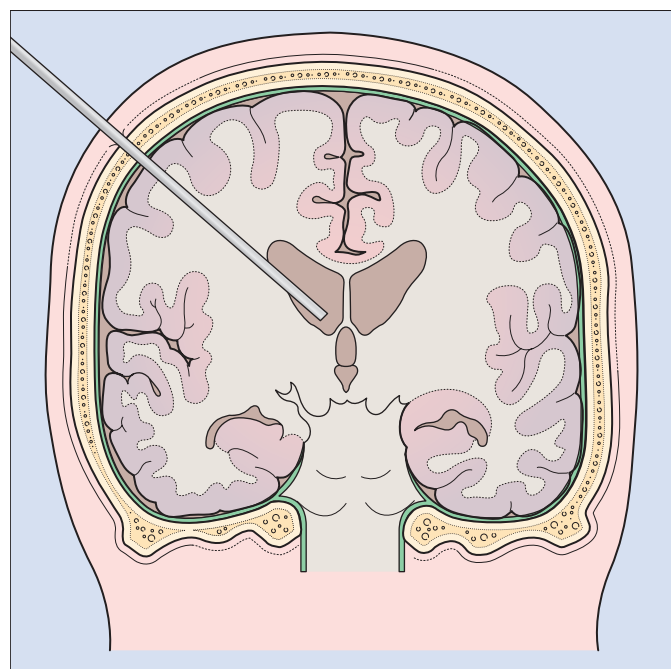


Figure 10.13 The approach angle for colloid cyst removal using the endoscope. A burr hole is made 7 cm from the midline and 8 cm from the nasion. Note: stereotactic guidance is invaluable to plan the best trajectory.

- moderate to low vascularity;
- soft consistency;
- less than 2 cm in diameter;²⁸
- associated secondary hydrocephalus;
- histologically low grade.

The principles of endoscopic tumor surgery of the ventricle include:

- A trajectory that avoids eloquent structures but allows a good view of the tumor.
- The outside of the tumor is coagulated with either monopolar electrocautery or a laser.
- Copious irrigation is used both to clear blood and debris and to prevent too much heat from building up inside the ventricle. Cysts are opened and drained, with the contents removed via suction or piecemeal.
- Remaining wall is coagulated and removed piecemeal.
- Hemostasis is obtained with copious irrigation.

With completion of the procedure, the scope is withdrawn while inspecting the tract for intraparenchymal bleeding. Endoscope-assisted microsurgical techniques are particularly applicable to tumors such as sellar tumors, clival chordomas, pineal lesions and intraparenchymal tumors adjacent to the brainstem or cranial base.^{29,30}

Considerable benefit is obtained by adding endoscopy to a traditional craniotomy. The tumor pathology frequently extends at acute angles to the cranial base or to the cortical surfaces along which the traditional surgical approach is made. While these avenues are inaccessible to the microscope, which requires a direct line of sight, they are ideal for endoscopy. The degree of retraction required can frequently be lessened substantially by endoscopic examination. When working around the brainstem and cranial nerves, the corridor available to the microscope is often very narrow, as extensive retraction is frequently not an option. The endoscope allows the surgeon to obtain the maximum possible access via the spaces naturally present in the extra-axial compartment.

ENDOSCOPE-ASSISTED MICROSURGERY

This is the most rapidly growing area in endoscopic neurosurgery. Microsurgery evolved to maximize visualization and minimize retraction. Endoscopy allows the neurosurgeon to move another step further towards achieving these goals. Endoscope-assisted microsurgery permits previously inaccessible or poorly accessible tumors located in the skull base, within narrow cavities, deep to key vascular or neural structures, or around corners in the intracranial space, to be clearly visualized and resected. The acutely angled rigid and flexible scopes allow the surgeon to look "around corners" which can be extremely useful in the extirpation of tumors and the clipping of aneurysms. Several approaches to the extra-axial structures of the skull base have been defined to improve visualization without jeopardizing standard microsurgical techniques. The most commonly adopted method is to place the endoscope down the same operative field. This creates no further morbidity but tends to clutter the already limited operative field. To avoid cluttering of instruments down an already limited craniotomy the scope may be inserted through a contralateral burr hole. Access to the subarachnoid space can be achieved through a small supra-orbital incision and then standard microsurgical dissection is performed to identify the pathology. Once the pathology is in view, the scope is fixed in place and attention is focused on the ipsilateral side. This technique, for example, offers excellent visualization of the tips of an aneurysm clip or the contralateral extent of a tumor.

Endoscopy is increasingly used to inspect tumors, tumor resection beds, aneurysms, and other pathology. Various authors

have discussed the advantages of endoscopy for these purposes.^{18,24,29,31} A summary of the advantages of the endoscope as an adjunct to microsurgery includes:

- Better definition of the normal and pathological anatomy. The endoscope can be used to clarify the anatomy such as key neural or vascular structures. This may be particularly important when working around or within the brainstem, between small perforating vessels, or between the cranial nerves.
- Identification of tumor portions located behind, or adherent to, vital structures. Some portions of tumor which are apparently invasive into the brain have brain-tumor interfaces that can be identified when visualized at more direct angles than is possible with the operating microscope alone.
- Minimization of retraction. The endoscope allows very narrow corridors to be used, reducing the need to displace sensitive structures.
- Assessing adequacy of tumor removal (Figures 10.14–10.16) or aneurysm clip placement.
- As a teaching tool. The endoscope offers a superior and often novel view of the anatomy, which can be beneficial to residents' understanding of the surgical approach. Furthermore, the operating surgeon and the student share the same view, which is not always true even with an operating microscope.

The most dangerous aspect of using the endoscope is the risk of impacting upon structures while introducing the endoscope. It is important to guide the endoscope by viewing it along the length of its barrel, rather than watching the image on the screen. After placing the endoscope into the working area, it is essential to continue to mind the shaft: if the scope is not fixed, then small, barely noticeable movements at the tip can be the result of larger excursions at the back of the scope, which can have potentially

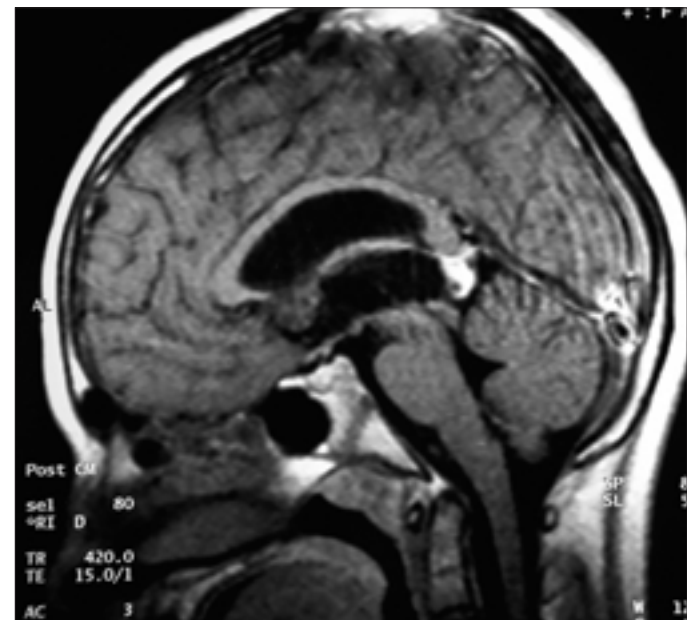


Figure 10.14 Note the enhancing pineal region tumor on the midsagittal magnetic resonance image. Resection was initially planned using the microscope alone.

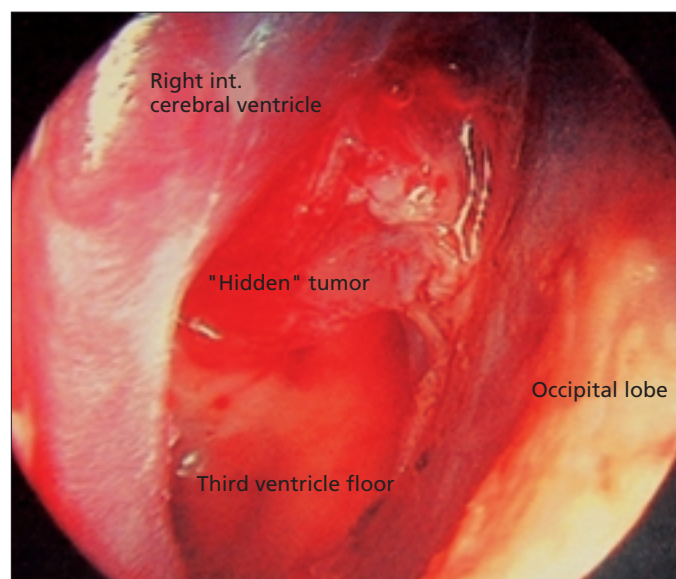


Figure 10.15 Following "complete" resection, a 30° endoscope was introduced which demonstrated residual tumor remnants.

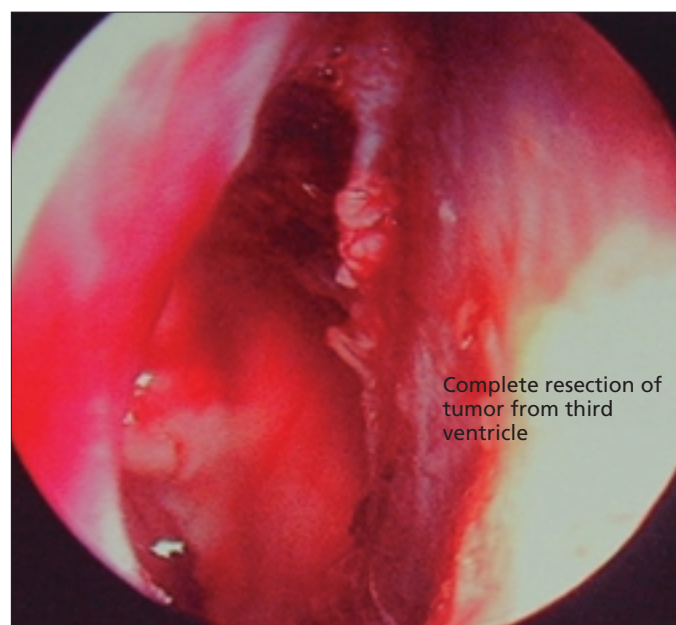


Figure 10.16 Using endoscope-assisted techniques, the "hidden" tumor was resected.

disastrous consequences. The use of a fixed endoscope holder can aid the surgeon to work with both hands. This will allow the surgeon to use more complex instruments, and will also prevent the endoscope from drifting against vital structures located superficially along the operative corridor.

ENDOSCOPIC TRANSSPHEOIDAL SURGERY

Since the turn of the century, the transsphenoidal route to the pituitary fossa has been advocated as a less invasive means of removing tumors than the transcranial route. However, sinonasal

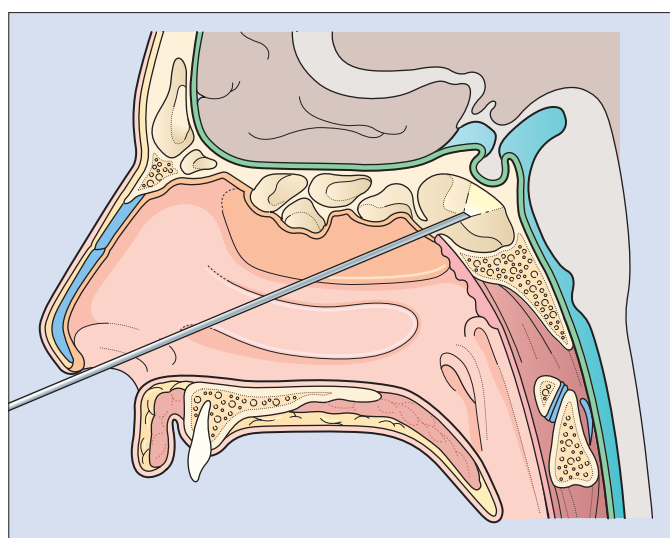


Figure 10.17 Approach made by the endoscope into the sphenoid sinus via the transnasal route.

complications are not infrequent, visualization is limited and an incision through the nose or gum is required. Our otolaryngology colleagues have been mastering the art of sinonasal endoscopy for many years and are comfortable operating in the sphenoid sinus.³²

It seemed only natural to progress one step further by taking the endoscope through the sphenoid sinus and into the pituitary fossa. The use of the endoscope allows close inspection and differentiation between tumor tissue and glandular remains. This results in microdissection of the tumor with maximum preservation of pituitary function. The angled view of the endoscope aids total gross removal of tumor tissue from the less accessible supra- and parasellar extensions.

There are several benefits of endoscopy over the gold standard which is the microsurgical approach. First, access to the sphenoid sinus is obtained by expanding the osteum after passing the scope directly through the nose. This obviates the need for a sublabial incision and a subperichondrial tunnel. Second, the scope provides better illumination of the surgical field and greater magnification. Third, by changing the angle of the scope from 0° to 30° or 70° one can expand the operative field and even look "around corners" (Figure 10.17). Finally, cluttering of instruments down a limited tunnel, such as the nasal speculum used with the standard microsurgical technique, can be avoided by placing the scope down one nostril and the instruments down the other. When the sphenoid sinus is reached, instruments and technique are similar to the microsurgical approach. Pituitary tumors with or without suprasellar extension can be removed in this fashion. Indeed, visualization is so good (Figure 10.18) that tumors of the parasellar region may also be approached using this technique. The cavernous sinuses, the tuberculum sella and the upper third of the clivus are all within reach of the endoscope (Figure 10.19).

MICROVASCULAR DECOMPRESSION

Endoscope-assisted microvascular decompression (MVD) is a potentially major advancement as improved visualization of the fifth cranial nerve should theoretically increase the number of successful MVDs, and ultimately improve the procedure's success

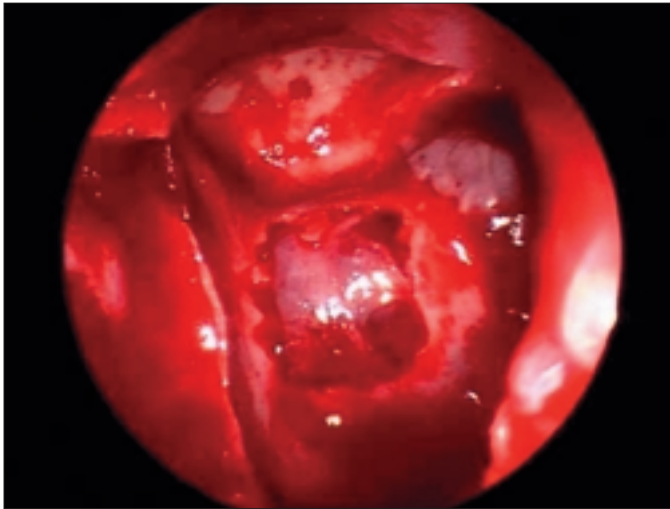


Figure 10.18 The endoscope offers a superior view of the sellar and regions adjacent. Bone removal here is complete, ready for dural opening and resection of tumor.

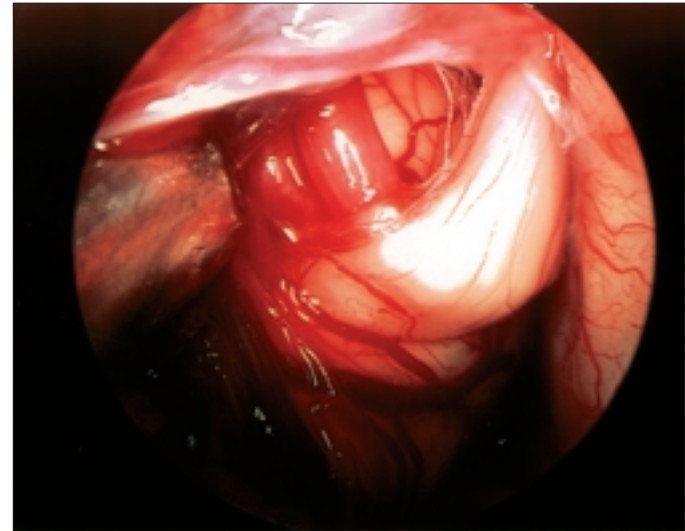


Figure 10.20 A superior view of nerve-vessel conflicts can be achieved with the endoscope. Here the trigeminal nerve is distorted at a right angle by an anterior inferior cerebellar artery (AICA) loop.



Figure 10.19 Care should be taken to position the endoscope monitor and frameless stereotaxis equipment to aid surgeon comfort and reduce neck fatigue.

rate in both the short and long term. Endoscope-assisted MVD for hemifacial spasm has also been described by some authors.

Endoscope-assisted microsurgery has been shown to improve the surgeon's visualization of structures in the extra-axial space³³ and endoscopic anatomy of the cerebellopontine angle has been published in detail.³⁴ Our unit has performed over 70 endoscope-assisted MVD procedures since 1994, finding a nerve-vessel conflict in all cases (Figures 10.20–10.22).

As this technique is likely to increase in prominence, we shall describe the operative technique in brief.

- Positioning: lateral decubitus or supine position with the head tilted away as far as their individual neck mobility permitted.
- Craniotomy: a small retrosigmoid craniectomy just inferior to the transverse-sigmoid junction.
- Dura opened and reflected against the sinus.
- Using standard microneurosurgical techniques the

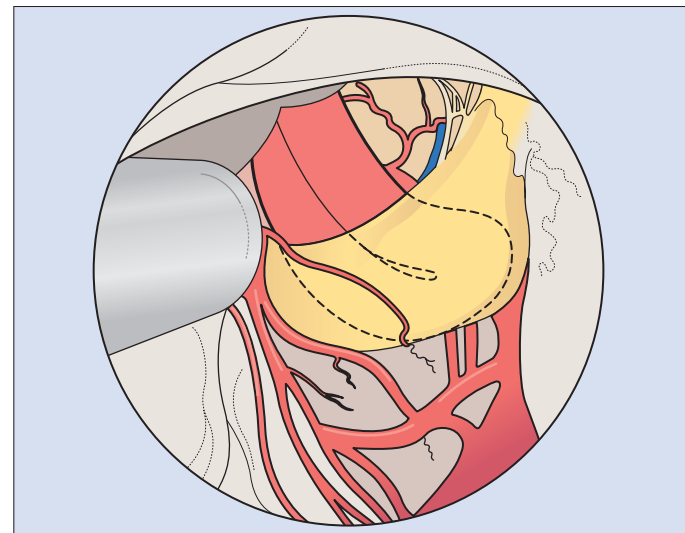


Figure 10.21 The endoscope was used to appreciate the anatomy of the loop in more detail. After endoscopic inspection, the surgeon now has a "mental picture" in far more detail than would be possible with a microscope.

trigeminal nerve is identified by gently retracting the cerebellum, releasing CSF from the basal cisterns and lysing the arachnoidal bands.

- Microscopic then endoscopic inspection with a 30° rigid scope.
- If the compressing vessel is seen only with the endoscope, MVD is performed under endoscopic control. If the vessel could be seen clearly with the microscope then the endoscope is used to assess the competency of decompression at the completion of the procedure.
- MVD is achieved by using a small Dacron® patch placed securely between the root entry zone of the nerve and the offending vessel.
- Closure by standard techniques.

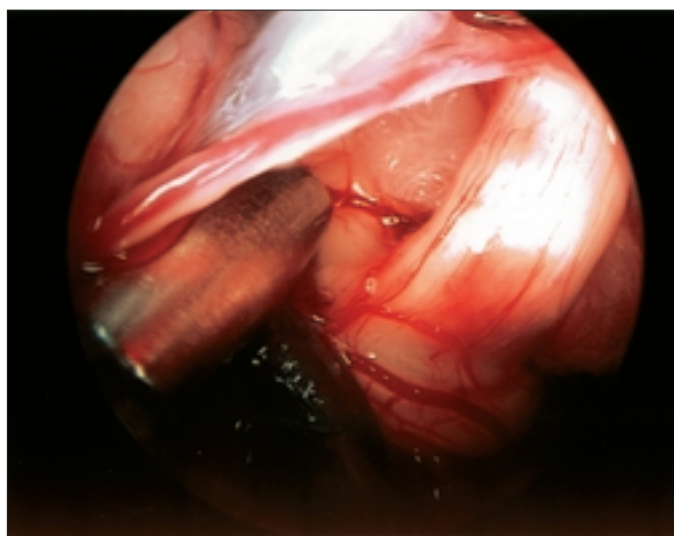


Figure 10.22 Appreciation of the anatomy now enables the surgeon to perform accurate placement of a patch. Note that the tension on the trigeminal nerve is now released.

The current gold standard is exploration with an operating microscope. However, the microscopic view is limited to the line of sight between the craniectomy and the lateral surface of the nerve, whereas compression may occur anywhere around the circumference of the nerve or anywhere along its length. All areas of potential nerve–vessel conflict are easily accessible with the endoscope. Jarrahy and colleagues reported on endoscope-assisted MVD³⁵ and found that 28% of compressive vessels were seen only with endoscopy. In addition, the treatment of 24% of patients with microscope-guided decompression was found to be inadequate and required revision under endoscopic guidance.

MISCELLANEOUS APPLICATIONS

Hypertensive intracerebral hematomas are usually deep within the basal ganglia, causing neurological deficits that can be limited by evacuation. As they are usually deep, standard surgery involves a cortical incision and retraction. Endoscopy allows aspiration of a hematoma,³⁶ coagulation of bleeders within the cavity and biopsy of the wall all under direct vision. This may be a reasonable adjuvant or alternative therapy for this patient population.

Some neurosurgeons are offering endoscopic removal of these blood collections through a burr hole (Figure 10.23). They claim adequate hematoma removal, satisfactory control of the bleeding source, lower morbidity, less blood loss, and shorter operating times.³¹ There are no randomized data to support these claims to date. Further study on this subject is required. There are, in addition, scattered reports of endoscope-assisted procedures including vestibular neurectomy³⁷ and posterior fossa decompression.³⁸

COMPLICATIONS OF NEUROENDOSCOPY

The endoscope is a powerful tool but, like all tools, it requires experience for safe and effective use. Practice is required to develop the visuomotor skills necessary to guide the tip safely in and out of narrow spaces. If an operation is to be performed primarily using endoscopic techniques, the surgeon must exercise

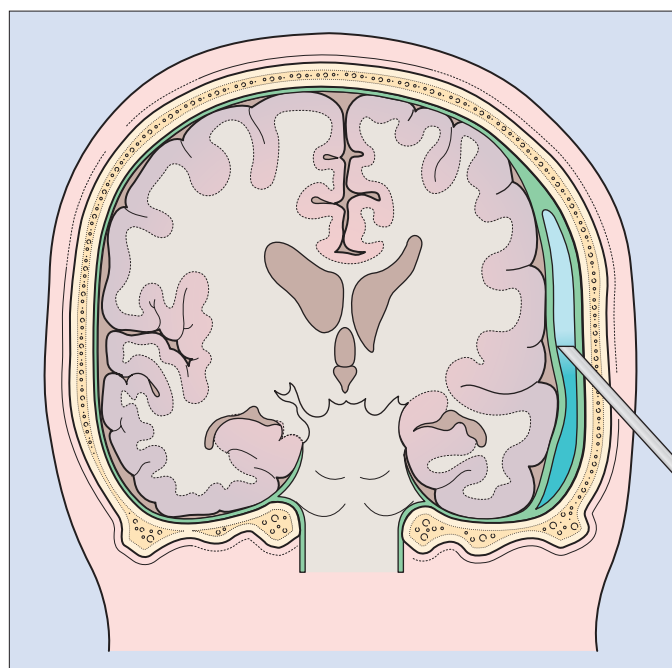


Figure 10.23 Endoscopy can aid in visualizing subdural remnants or loculations via the burr hole exposure.

considerable judgment to determine when the procedure may no longer be possible through an endoscopic approach, and must plan for an open microsurgical approach (Figure 10.24).

A familiarization with the endoscopic perspective and a review of the pertinent microsurgical anatomy is essential before using the endoscope on patients. Used properly, complications directly related to the endoscope can be minimized. It is hypothesized that the incidence of intraoperative complications decreases with experience, while that of the longer-term sequelae do not, highlighting the steep learning curve with this approach.³⁹ Lastly, a number of technical issues related to the use of the endoscope have been raised in this chapter. One of the most frequently cited concerns is the fact that the view the endoscope provides is only two-dimensional. Certainly one traverses a steep learning curve in the process of attaining the visuomotor skills necessary to work comfortably using a two-dimensional video image. While disorienting for the novice endoscopist, this theoretical limitation seldom presents much difficulty for most surgeons once they become familiar with it.

CONCLUSIONS

The clear advantages of neuroendoscopy are:

- increased light intensity while approaching an object;
- clear depiction of details in close-up;
- extended viewing angle.

One of the goals of the use of the endoscope is to reduce brain retraction and minimize cortical and nerve manipulation. These characteristics are translated into potential advantages during surgical procedures for deep-seated lesions in narrow spaces. The potential rewards of neuroendoscopy include improved postoperative results, shorter hospitalization times, and fewer postoperative complications. They are striking arguments for the use of this operative technique for specific well-defined indications.



Figure 10.24 An incision is marked for an endoscopic colloid cyst removal. In the event of failure of the endoscopic technique, the dotted line marks the extended incision to perform an open craniotomy.

CLINICAL PEARLS

- Neuroendoscopy is a rapidly evolving field which adheres to the principles of minimally invasive surgery: maximum results through minimal exposures with safety by applying superior magnification and illumination. Neuroendoscopy is safe and effective in experienced hands but has a steep visuomotor learning curve. The risks and complications of this technique include vascular or neural injury and may be minimized by developing improved visuomotor skills and applying appropriate case selection. In addition, the surgeon must be prepared to convert a neuroendoscopic procedure into a standard microsurgical procedure if the procedure is not technically feasible with the endoscope.
- The indications for this exciting surgical technique of neuroendoscopy are swiftly expanding from intraventricular pathology to extra-axial pathology. Currently, widely accepted indications of neuroendoscopy include: (1) endoscopic third ventriculostomy for the treatment of hydrocephalus from aqueductal stenosis or posterior fossa tumors; (2) fenestration of loculated ventricles; (3) resection of intraventricular lesions such as cysts, colloid tumors, and small avascular tumors; (4) biopsy of pineal region tumors; (5) resection of pituitary and sellar tumors; (6) treatment of arachnoid cysts and selected extra-axial pathology; and (7) as an adjuvant in endoscope-assisted microsurgery for tumor resection, aneurysm clipping, microvascular decompression and skull-base surgery. This is a powerful tool with increasing applications but known limitations.

REFERENCES

1. L'Espinasse VL. *Neurological Surgery*, 2nd edn. Philadelphia: Lea and Ferbiger; 1943: 442.
2. Dandy WE. An operative procedure for hydrocephalus. *Bull Johns Hopkins Hosp* 1922; 33: 189–90.
3. Yokoh A, Sugita K, Kobayashi S. Intermittent versus continuous brain retraction: an experimental study. *J Neurosurg* 1983; 58: 918–23.
4. Perneczky A, Fries G. Endoscope-assisted brain surgery: Part I Evolution, basic concept, and current technique. *Neurosurgery* 1998; 42: 219–25.
5. Teo C. Endoscopic-assisted tumor and neurovascular procedures. *Clin Neurosurg* 2000; 46: 515–25.
6. Alberti O, Riegel T, Hellwig D, Bertalanffy H. Frameless navigation and endoscopy. *J Neurosurg* 2001; 95: 541–3.
7. Scarff JE. Endoscopic treatment of hydrocephalus: description of a ventriculoscope and preliminary report of cases. *Arch Neurol Psychiatr* 1936; 35: 853–60.
8. Guiot G. Ventriculo-cisternostomy for stenosis of the aqueduct of Sylvius. *Acta Neurochir (Wien)* 1973; 28: 275–89.
9. Hopf N, Grunert P, Fries G, Resch K, Perneczky A. Endoscopic third ventriculostomy: Outcome analysis of 100 consecutive procedures. *Neurosurgery* 1999; 44: 795–804.
10. Buxton N, Ho KJ, Macarthur D, Vloeberghs M, Punt J, Robertson I. Neuroendoscopic third ventriculostomy for hydrocephalus in adults: report of a single unit's experience with 63 cases. *Surg Neurol* 2001; 55: 74–8.
11. Cinalli G, Saint-Rose C, Chumas P, Zerah M, Brunelle F, Lot G, Pierre-Kahn A, Renier D. Failure of third ventriculostomy in the treatment of aqueductal stenosis in children. *J Neurosurg* 1999; 90: 448–54.
12. Teo C, Young R. Endoscopic management of hydrocephalus secondary to posterior third ventricular tumors. *Neurosurg Focus* 1999; 7(4): article 2.
13. Kanner A, Hopf NJ, Grunert P. The "optimal" burr hole position for endoscopic third ventriculostomy: results from 31 stereotactically guided procedures. *Minim Invas Neurosurg* 2000; 43: 187–9.
14. Saint-Rose C, Cinalli G, Roux FE, et al. Management of hydrocephalus in paediatric patients with posterior fossa tumours; the role of endoscopic third ventriculostomy. *J Neurosurg* 2001; 95: 791–7.
15. Barlow P, Ching HS. An economic argument in favour of endoscopic third ventriculostomy as a treatment for obstructive hydrocephalus. *Minim Invas Neurosurg* 1997; 40: 37–9.
16. Hader WJ, Drake J, Cochrane D, Sparrow O, Johnson ES, Kestle J. Death after late failure of third ventriculostomy in children. Report of three cases. *J Neurosurg* 2002; 97: 211–15.
17. Tisell M, Almstrom O, Stephenson H, Tullberg M, Wikkelsö C. How effective is endoscopic third ventriculostomy in treating adult hydrocephalus caused by primary aqueductal stenosis? *Neurosurgery* 2000; 46: 104–9.
18. Brockmeyer D, Abtin K, Carey L, Walker ML. Endoscopic third ventriculostomy: an outcome analysis. *Paediatr Neurosurg* 1998; 28: 236–40.
19. Teo C, Jones R. Management of hydrocephalus by endoscopic third ventriculostomy in patients with myelomeningocele. *Paediatr Neurosurg* 1996; 25: 57–63.
20. Walker ML, Perronio J, Carey CM. Ventriculoscopy. In: Cheek WR (ed.). *Pediatric Neurosurgery*, 3rd edn. Philadelphia: WB Saunders; 1993: 572–81.
21. Perneczky A, Muller-Forell W, van Lindert E, Fries G. *Keyhole Concept in Neurosurgery*. Stuttgart: Thieme; 1999: 120–48.

12 Neuroendoscopy

22. Wallner KR, Gonzales M, Sheline GE. Treatment of oligodendrogliomas with or without post-operative irradiation. *J Neurosurg* 1988; 68: 684–8.
23. Garcia DM, Fulling KH. Juvenile pilocytic astrocytomas of the cerebrum in adults. A distinctive neoplasm with favorable prognosis. *J Neurosurg* 1985; 63: 382–6.
24. Lewis AI, Crone KR, Taha J, et al. Surgical resection of third ventricle colloid cyst. Preliminary results comparing transcallosal microsurgery with endoscopy. *J Neurosurg* 1994; 81: 174–8.
25. Teo C. Endoscopic removal of colloid cysts: issues of safety and reliability. *Neurosurg Focus* 1999; 6(4): article 9.
26. Rodziewicz GS, Smith MV, Hodge CJ. Endoscopic colloid cyst surgery. *Neurosurgery* 2000; 46: 655–62.
27. Oka K, Kin Y, Go Y, et al. Neuroendoscopic approach to tectal tumors: a consecutive series. *J Neurosurg* 1999; 91: 964–70.
28. Gaab MR, Schroeder HWS. Neuroendoscopic approach to intraventricular lesions. *J Neurosurg* 1998; 88: 496–505.
29. Abdullah J, Caemart J. Endoscopic management of craniopharyngioma: a review of 3 cases. *Minim Invas Neurosurg* 1993; 38: 79–84.
30. Cohen AR, Perneczky A, Rodziewicz GS, et al. Endoscope-assisted craniotomy: approach to the rostral brainstem. *Neurosurgery* 1995; 36: 1128–30.
31. Gamea A, Fathi M, el-Guindy A. The use of the rigid endoscope in trans-sphenoidal pituitary surgery. *J Laryngol Otol* 1994; 108: 19–22.
32. Perneczky A, Tschabitscher M, Resch KDM. *Endoscopic Anatomy for Neurosurgery*. Stuttgart: Thieme 1998: 91–8.
33. Matula C, Tschabitscher M, Day JD, et al. Endoscopically assisted microneurosurgery. *Acta Neurochir (Wien)* 1995; 134: 190–5.
34. Jarrahy R, Berci G, Shahinian HK. Endoscope-assisted microvascular decompression of the trigeminal nerve. *Otolaryngol Head Neck Surg* 2000; 123: 218–23.
35. Kim MH, Kim EY, Song JH, Shin KM. Surgical options of hypertensive intracerebral hematoma: stereotactic endoscopic removal versus stereotactic catheter drainage. *J Korean Med Sci* 1998; 13: 533–40.
36. Karakhan VB, Khodnevich AA. Endoscopic surgery of traumatic intracranial haemorrhages. *Acta Neurochir Suppl (Wien)* 1994; 61: 84–91.
37. Wackym PA, King WA, Barker FG, Poe DS. Endoscope-assisted vestibular neurectomy. *Laryngoscope* 1998; 108: 1787–93.
38. Mobbs RJ, Teo C. Endoscopic assisted posterior fossa decompression. *J Clin Neurosci* 2001; 8: 343–4.
39. Teo C, Rahman S, Boop FA, Cherny B. Complications of endoscopic neurosurgery. *Childs Nerv Syst* 1996; 12: 248–53.
40. Dalrymple SJ, Kelly PJ. Computer assisted stereotactic third ventriculostomy in the management of noncommunicating hydrocephalus. *Stereotact Funct Neurosurg* 1992; 54: 105–10.
41. Jones RF, Kwok BC, Stening WA, Vonau M. The current status of endoscopic third ventriculostomy in the management of non-communicating hydrocephalus. *Minim Invas Neurosurg* 1994; 37: 28–36.
42. Choi JU, Kim DS, Lim SH. Endoscopic surgery for obstructive hydrocephalus. *Yonsei Med J* 1999; 40: 600–7.
43. Gangemi M, Donti P, Maiuri F, Longatti P, Godano U, Mascari C. Endoscopic third ventriculostomy for hydrocephalus. *Minim Invas Neurosurg* 1999; 42: 128–32.
44. Fukuhara T, Vorster SJ, Luciano MG. Risk factors for failure of endoscopic third ventriculostomy for obstructive hydrocephalus. *Neurosurgery* 2000; 46: 1100–11.