EUROENDOSCOPY promises to revolutionize current and future neurosurgical techniques. All other surgical specialties have readily adopted minimally invasive techniques, thus giving rise to subspecialties like arthroscopy, laparoscopic abdominal surgery, thoracoscopy, and endoscopic sinus surgery. Unfortunately, neurosurgery has lagged behind in this trend until recently. During the last decade, however, significant improvements have occurred in neuroendoscopic instrumentation.

Most improvements in surgical instrumentation arise from surgeons demanding more from their instruments and making suitable innovations that allow for greater surgical precision and possibilities. Yaşargil, Rhoton, and Malis have driven the microneurosurgical revolution by their detailed anatomical studies and development of newer instruments. Griffith, Fukushima, and Pernecky have made similar contributions in the field of neuroendoscopy.

Handling multiple instruments with only two hands while performing surgery continues to pose a challenge in neuroendoscopic procedures. Achieving hemostasis while in the depths of the brain also represents a significant problem in a few cases. In this paper, we describe a new neuroendoscopic instrumentation system that overcomes some of these problems.

Clinical Material and Methods

Description of Instrumentation

The system described in this article contains the following components.

Outer Sheath. A simple laparoscopic trocar and cannula (Kalelkar, Mumbai, India) is used. The tip of the trocar is blunted (Fig. 1 left). The diameter of the working channel is 7.5 mm and its length is 150 mm. There are no preformed subchannels for other instruments, allowing for greater freedom of movement.

Three-in-One Device. A 0˚ Hopkins rigid telescope having a length of 180 mm and a diameter of 4 mm is used as the basic optical device. A 1-mm-diameter Teflon-coated insulated wire and a No. 16 French CVP line are fixed to the telescope with the help of thin shunt tubes (Fig. 1 left and right). The insulated wire is used as a monopolar cut-
ting/coagulating device and the CVP tubing is used for irrigation and suction. Because of rigid fixation, all three instruments (telescope, electrode, and irrigation tubing) move together and the views featured in Fig. 2 (a–c) can be obtained. The length and orientation of the electrode and the irrigation channel can be adjusted by moving them along the length of the telescope or around it, depending on the indication. It is also possible to bend the electrode to bring it closer to a particular structure in the case of difficult-to-approach anatomy. A cross-section of the entire system is illustrated in Fig. 3.

Fixation Device. A Gigli guide is bent (Fig. 4) and curved around the working channel. The guide and channel are then fixed using the Leyla retractor. This provides rigid fixation of the outer sheath in any plane. The entire surgical procedure is performed with the three-in-one device in the right hand and the fourth instrument in the left hand (Fig. 2d). Given that the outer sheath is very lightweight and that no other instruments are affixed to it, the moderate fixation afforded by the improvised Leyla system proves to be very effective in all cases.

Manipulating Instruments. Instruments used for microlaryngectomy (Kalelkar) have been adapted for neuroendoscopy. Punch biopsy forceps, grasping forceps, and microscissors are available. The diameter of the shaft of the manipulating instruments is 2 mm and the length is 300 mm.

Other Accessories. A single-chip camera (Storz-Telecam DX; Karl Storz GmbH and Co., Tuttingen, Germany), 175-W xenon light source (Storz Xenon-Nova; Karl Storz GmbH and Co.), a television (with audiovisual input; Akai, Tokyo, Japan), and a videocassette recorder unit (Akai) are the other accessories used in this study.

Surgical Technique

The system described herein has been used mainly for intraventricular procedures and the evacuation of intracerebral hematomas. Details of the operative technique for the former are described here; those for the latter procedure will be described in a separate article.

The intraventricular procedures were initially performed...
via appropriately placed 15-mm burr holes, but later in the series we shifted to a 15-mm craniotomy performed with a trephine, which allowed the bone flap to be replaced. After opening the dura mater and coagulating the pia mater, the ventricle is initially tapped with a brain needle and then entered by the three-in-one device while irrigating with Ringer lactate. This solution provides a fluid interface between the tip of the telescope and the brain matter, thereby protecting the former. Once the ventricle has been entered, the anatomical landmarks are identified (choroid plexus, thalamostriate vein, and foramen of Monro) and the feasibility of performing the definitive procedure is assessed. We then remove the endoscope and pass the trocar cannula into the ventricular system. This outer sheath is fixed over the region of interest with the aid of the Leyla retractor system (Figs. 1 left and 4). At this point, the outer sheath now forms a safe corridor to the operative field through which instruments can be passed as many times as necessary without causing any significant retraction or manipulation of the brain parenchyma. The telescope together with the three-in-one device is not fixed to this outer sheath; rather, it is held in and manipulated by the right hand (Fig. 2d). This free movement of the optical instrument along with the cautery and the irrigation tubing within the rigidly fixed outer channel is a particular advantage of this system, allowing the neurosurgeon to manipulate deep structures without significantly disturbing the more superficial ones.

The monopolar electrode of the three-in-one device is advanced forward to bring it into view (Fig. 2a–c), and the device is inserted into the ventricle. During third ventriculostomy, the outer sheath is fixed just outside the foramen of Monro (Fig. 2a) and only the three-in-one device is passed into the third ventricle (Fig. 2c). The initial ventriculostomy is performed either by blunt perforation with

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**Fig. 3.** An illustration depicting the cross-section of the three-in-one device positioned within the working channel. Much space is available for the introduction and manipulation of a fourth instrument.

**Fig. 4.** Photograph of an improvised method of fixing the outer sheath. A bent Gigli guide goes around the working channel and is immobilized with the Leyla retractor.
the monopolar electrode or, if the floor of the third ventricle is too tough, by passing very low current through the electrode while simultaneously irrigating to dissipate the heat. The stiff monopolar electrode can then be used as an endoscopic dissector to enlarge the ventriculostomy (Fig. 2e), a process that can also be achieved by dilating it with a balloon catheter held in the left hand. The use of the monopolar electrode as a dissector is a unique capability of this system, allowing for deep surgical manipulation without the need for retracting surrounding brain. The fourth instrument held in the left hand has an extensive degree of freedom and can be manipulated to any point of the 360° field of vision (Fig. 2d).

The three-in-one neuroendoscopic system has been used in clinical testing in 83 patients at the Vidyasagar Institute of Mental Health and Neurosciences since May 1998. The types of procedures performed are listed in Table 1.

### System Costs

The cost of any new instrumentation system plays a significant role in its acceptability. At the time the system was developed (May 1998), the complete three-in-one unit (including all accessories and an additional 30°, 4-mm rigid telescope; Storz) cost approximately $8000. This figure compares favorably with those of other available systems in the range of $20,000 to $30,000.

### Results

Experience gained during these operations has demonstrated that the new system is reliable and effective. Table 1 lists the types of procedures performed. Two patients had moderate intraventricular bleeding intraoperatively: one from the anterior septal vein during septostomy and the other from a basilar artery perforating vessel. On both occasions, the bleeding was successfully controlled with gentle irrigation. In one patient the third ventriculostomy had to be abandoned because of unfavorable anatomy. The detailed clinical profiles, complications, and results of these operations will be presented in another paper. Many advantages of the new system have been noticed.

### Automatic Alignment

The three instruments combined move together, converting the telescope from an optical device into a surgical instrument that can be used for cutting and coagulation. Irrigation and coagulation are automatically aligned with themselves and with the optics. All cutting and coagulating are performed under irrigation, thus dissipating the heat generated. In the case of a bleeding vessel, high-flow irrigation clears the field and allows coagulation of the vein in view. Excess irrigation fluid drains out of the working channel, which prevents a dangerous increase in intracranial pressure.

### Additional Instruments

A fourth instrument can be introduced into the system with the other hand. Fogarty catheters, grasping forceps, and fine suction tubes are commonly used. An extensive amount of space within the outer sheath is available for the fourth instrument because there are no preformed channels that might limit rotatory mobility. By rolling the fourth instrument on its own axis, it can be taken into any part of the round endoscopic field of vision. This minimizes the manipulation of the outer sheath, thus reducing brain retraction and injury.

### Increased Freedom

The length of the electrode and the irrigation tubing can be adjusted based on the existing situation. Sometimes, in cases involving difficult-to-approach anatomy, it is advantageous to have a long coagulation electrode, especially if it can be manipulated in any part of the visual field. The system described herein allows for such freedom. In addition, this instrument allows for the manipulation of deep-seated brain structures by using the rigidly fixed electrode like a microdissector. Automatic visual alignment with the telescope and absence of preformed instrument channels facilitate dissection. Another advantage is the ability to rotate the cautery electrode and to fix it anywhere in the 360° field of vision. One must simply withdraw the telescope, rotate the electrode to the desired position, and reinsert the telescope. This can be particularly useful in restricted spaces in the depths of the brain.

### No Assistant Required

The system described in this paper allows complex neuroendoscopic procedures to be performed without a specially trained assistant. As the operating neurosurgeon handles all the instruments, the assistant’s role is reduced to pushing irrigating fluid, a task the scrub nurse can comfortably perform.

### Discussion

The field of neuroendoscopic instrumentation is undergoing rapid development. Attempts to improve the instruments include developing newer electrosurgical units, malleable endoscopic suction instruments, and application of LASER for better hemostasis. Some surgeons have even created a second working portal for neuroendoscopic procedures to allow for the passage of more instruments into the working area.

A theme common to most currently available neuroendoscopic instruments is the presence of preformed subchannels in the main channel through which the telescope is introduced. Smaller instruments like monopolar cautery electrodes and irrigation tubes and so forth are passed through these subchannels. We found this to be a major hin-
A novel multipurpose neuroendoscopic system
drance because it limits the maneuverability of the instruments. If, for example, the monopolar electrode must be moved from the 3 o’clock position to the 8 o’clock position, the entire assembly must be rotated. This problem is over-
come by using our system. The electrode can be directly manipulated into the desired position by rotating it on its own axis, thus reducing the need to move the outer working channel.

Unfortunately, scissoring of the instruments is an occasional problem. This generally occurs when the three-in-one device is kept in the center of the outer sheath, reducing the space available to manipulate the fourth instrument. The problem is easily overcome by learning to keep the device toward the outer periphery of the sheath, especially when introducing the fourth instrument, and giving ample space for its manipulation.

Furthermore, attaching the monopolar electrode and irrigation tubing to the telescope allows the three-in-one assembly to be used as a hemostatic knife. Because the entire assembly moves together, no effort is required to align the electrode with the telescope. Irrigation fluid is automatically directed at the point where coagulation is taking place, thus dissipating the blood and heat effectively. Most importantly, the three-in-one system leaves the other hand free to introduce a fourth instrument and opening up many surgical possibilities. An endoscopic cavitronic ultrasonic aspirator system is now available, which if combined with the three-in-one device may allow for the resection of deep-seated brain tumors with endoscopic visualization.

One criticism of the system described in this paper might be that the outer sheath is too large—7.5 mm. This size was carefully chosen, however, to compromise between the need for versatility and that for minimal invasiveness. Many commercially available systems have an outer diameter of only 4 to 6 mm. These smaller systems may be used comfortably for only routine intraventricular cerebrospinal fluid diversion procedures, however. Any tumor or colloid cyst resection becomes prolonged and tedious given the narrow width of the instrument channels. In fact, there is an increasing tendency among neurosurgeons to design and use systems with outer diameters approaching 7 mm, as reported by Gaab and Schroeder, a leading team involved in endoscope design. These slightly larger scopes allow for tumor resection, hematoma removal, and better intraventricular manipulation without, in our opinion, unduly compromising minimal invasiveness.

Finally, cost considerations have become vital in the present health care system. Given that most of the accessories used in our device are modifications of readily available neurosurgical, laparoscopic, and otolaryngological instruments, the overall pricing of the system is very competitive and affordable. The camera, telescopes, and light sources were obtained from standard manufacturers. The system presented here costs less and is useful for more neurosurgical indications (intraventricular cerebrospinal fluid diversion procedures, intracerebral hematoma removal, deep-seated tumor resection, endoscope-assisted microsurgery), making it attractive to many neurosurgeons who may not otherwise consider investing time and effort in neuroendoscopy.

Conclusions

Our three-in-one neuroendoscopic system provides a safe corridor for working in the depths of the brain without excessive manipulating or retracting of surrounding brain parenchyma. The system is very versatile and effective. It also offers a significant cost advantage over other commercially available systems. Most importantly, it offers many opportunities toward development of additional neuroendoscopic instruments, which might increase the scope of endoscopic neurosurgery over the next few years.

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Disclosure

The authors have no financial interest in the instruments under discussion.

References

10. Rhoton AL Jr: Ring curettes for transsphenoidal pituitary opera-
tions. Surg Neurol 18:28–33, 1982

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