Endoscope-assisted Microsurgery for Microvascular Compression Syndromes

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OBJECTIVE: To discuss the results of endoscope-assisted surgery in microvascular decompression (MVD) of Cranial Nerves (CNs) V, VII, and VIII.

METHODS: Neuroendoscopy was used as an adjunct to the surgical microscope in the MVD of the trigeminal (17 patients), facial (10 patients), and vestibulocochlear (1 patient) nerves in a series of 28 consecutive patients. After a standard microsurgical approach to CNs V, VII, and VIII, the endoscope was used to inspect all aspects of neural anatomy, to assess vascular compression, and to check the results of the decompression. Endoscope use was graded in four categories: Grade I, used but no definite role; Grade II, visualization assisted; Grade III, procedure assisted; and Grade IV, primary role. The usefulness of the endoscope was evaluated in each case.

RESULTS: The endoscope was useful in visualizing the anatomy in all cases. It was especially useful in establishing trigeminal vein compression of CN V in Meckel's cave; observing multiple sources of vascular compression; ensuring adequate decompression after cauterization of vein, insertion of the Teflon felt, or a pexy procedure; and permitting observation of the compression of CN VII at the root exit zone by small arteries and veins. In six patients with trigeminal neuralgia, the trigeminal vein was cauterized and divided by using endoscopic vision only because the venous compression was not completely visualized with the microscope. During a follow-up period of 6 to 52 months (mean, 29 mo; median, 40 mo), all patients were asymptomatic and receiving no medication.

CONCLUSION: The endoscope is a useful adjunct to MVD in the treatment of trigeminal neuralgia, hemifacial spasm, and disabling positional vertigo or tinnitus.

KEY WORDS: Disabling positional vertigo or tinnitus, Hemifacial spasm, Microvascular decompression, Neuroendoscope, Trigeminal neuralgia

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Microvascular decompression (MVD) is an important surgical procedure in the management of trigeminal neuralgia (TGN) and hemifacial spasm (HFS), and it plays a role in other microvascular compression syndromes, such as disabling positional vertigo or tinnitus and glossopharyngeal neuralgia (1, 6–9, 19, 21, 22). Multiple sources of vascular compression are common, with both arteries and veins playing a part in compressing the nerve (10). The compression usually occurs at the root exit zone (REZ) of the nerve, but compression by the trigeminal vein (TGV) distally in Meckel's cave (MC) has also been described (5, 10, 11). Inadequate visualization of the first 2 to 3 mm of the nerve at the REZ, in MC, or in the inferior or anterior aspects of the nerve could be a cause of negative exploration and failure to relieve compression in a number of cases.

The endoscope has been used for cerebellopontine angle exploration in several series (1, 13, 16, 19). We have used the endoscope as an adjunct to the microscope in the MVD of CNs V, VII, and VIII in the treatment of TGN, HFS, and disabling tinnitus, and in this article we describe the usefulness of this technique.

PATIENTS AND METHODS

Neuroendoscopy was used in 28 nearly consecutive patients with TGN (17 patients), HFS (10 patients), and disabling tinnitus (1 patient) by the senior author (LNS) as an adjunct to MVD during a 33-month period ending November 2002. One of the patients had atypical TGN and ipsilateral HFS at the same time. Three patients with TGN underwent surgery without the use of an endoscope during the same period because the endoscope was not available as a result of technical problems.

Rigid rod lens endoscopes (2.7-mm diameter with 0- and 30-degree angulations), held in the surgeon's hand, were used during the procedure. They were introduced under microscopic vision to assist in placement. Endoscopic images were observed directly on a video screen, and for some patients, picture-in-picture technology (Olympus Microscope and Video Systems, Olympus America, Inc., Melville, NY) was available to observe both microscopic and endoscopic images. Such picture-in-picture technology was not available in most patients because of equipment limitations in the hospital.

After standard retrosigmoid craniotomy, the endoscope was used as an adjunct to the microscope during the procedure. The following steps were performed. After dural opening, the endoscope was used to visualize the cisterns and to look for aberrantly located veins that could be torn during routine cerebellar retraction (e.g., superiorly located cerebellar veins draining into tentorium). After Cranial Nerves (CNs) V, VII, or VIII were exposed, the endoscope was used to visualize the vessels compressing the nerve; in the cases of MVD of CNs VII and VIII, this was repeated during the operation to visualize small vessels (arterioles or veins) that were hidden by a large vessel such as the vertebral artery (VA) or the posteroinferior cerebellar artery. After decompression, the endoscope was used to confirm the completeness of the procedure. In patients undergoing MVD for TGN, the endoscope was used to visualize the brainstem REZ, the inferior and medial surface of CN V, and the region of MC to make sure that there were no vascular compressions in this area.

In some cases, the endoscope was also used to assist in the performance of a procedure such as the dissection or coagulation of a vein. The MVD procedure consisted of a pexy (securing the artery to the dura with a small stitch and incorporating Teflon felt, in some cases, to avoid vessel kinking) (2), interposing pieces of shredded Teflon felt between the nerve and artery (or arteries), and/or the cauterization of veins. Endoscope usefulness was classified into four grades, as follows: Grade I, used but no role; Grade II, visualization assisted; Grade III, procedure assisted; and Grade IV, used primarily.

TABLE 1. Endoscope-assisted microvascular decompression for patients with trigeminal neuralgia[a]

Findings and endoscope use	No. of patients
Compressing vessels	
1 vessel	
TGV	3
SCA	2
Scar tissue only	2
>1 vessel	
SCA, TGV	6
AICA, TGV	1
PICA, TGV	1
Dural band, TGV	1
Branches of petrosal vein	1
Procedure performed	
Decompression with Teflon felt	12
Cauterization of vein and division	8
Pexy of SCA to tentorium	4
Endoscope use	
Used but no role (Grade I)	0
Visualization assisted (Grade II)	11
Procedure assisted (Grade III)	6
Total no. of patients	17

[a] TGV, trigeminal vein; SCA, superior cerebellar artery; AICA, anteroinferior cerebellar artery; PICA, posteroinferior cerebellar artery.

RESULTS

The operative findings and endoscope usefulness in the patients with TGN are listed in *Table 1*. Ten patients had multiple vascular compressions, and three had TGV compression only. In eight patients, the superior cerebellar artery was one of the compressive vessels; two other patients had only scar tissue compressing the TGN at the entrance to MC. One patient had a dural band and TGV compression, and another patient had branches of the petrosal vein compressing the nerve root. The endoscope assisted in visualization of the anatomy in 11 patients (Grade II) and assisted in the performance of the procedure in 6 patients (Grade III). In the latter group, it was used to visualize TGV compressing the nerve root at the entrance to MC, then cauterize and section it with the endoscope (*Fig. 1*). The presence of a bony ridge posterior to CN V obscured the microscopic view of the entrance to MC in these patients, and the use of the endoscope allowed the vein to be visualized without the need to drill the bony ridge away. In one patient, the venous compression was the only nerve-vessel contact identified, but other arterial compressions were present in the remaining five patients. In two of these patients, the venous compression was visualized only endoscopically and was missed when the microscope alone was used.

In patients with HFS and disabling positional vertigo or tinnitus, significant cerebellar retraction near the flocculus of the cerebellum may be required to adequately visualize the REZ of CNs VII and VIII. This type of retraction often results in changes in the auditory brain response and may produce loss of hearing. The use of the endoscope reduced the extent and duration of retraction, although this is difficult to quantify. None of our patients who underwent surgery for HFS or for disabling tinnitus experienced postoperative hearing loss, as assessed by an audiogram.

All 10 patients with HFS and the single patient with disabling tinnitus had multiple vascular compressions of the nerve (*Table 2*), and the endoscope allowed the visualization of all compressive vessels not seen with the microscope (*Fig. 2*). The endoscope was also useful in inspecting the REZ to ensure

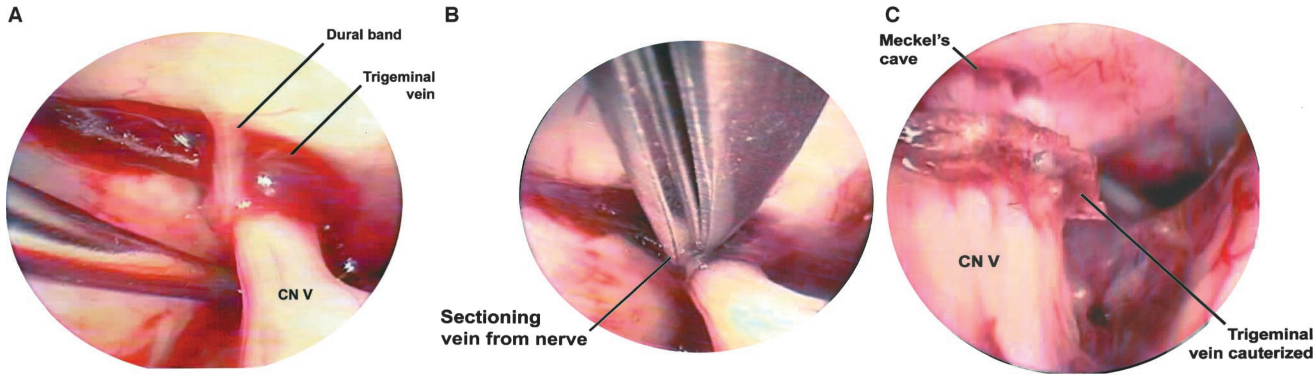

FIGURE 1. A, *endoscopic view of TGV and a dural band compressing the right CN V at MC.* B, *TGV cauterized and being sectioned with microscissors under endoscopic view.* C, *complete decompression of TGN at MC confirmed with the endoscope.*

TABLE 2. Endoscope-assisted microvascular decompression for patients with hemifacial spasm[a]

Findings and endoscope use	No. of patients
Compressing vessels	
AICA loop, small vein	2
AICA loop, small arteriole	1
PICA, small vein	1
AICA loop, PICA, small vein	2
VA, AICA loop, small vein	3
Two small veins	1
Procedure performed	
Decompression with Teflon felt	8
Cauterization of vein and section	8
Pexy of the involved artery	8
Endoscope use	
Visualization assisted (Grade II)	10
Procedure assisted (Grade III)	0
Total no. of patients	10

[a] AICA, anteroinferior cerebellar artery; PICA, posteroinferior cerebellar artery; VA, vertebral artery.

complete decompression. In 3 of 10 patients with HFS, the VA was pushing other vessels into CN VII. A pexy stitch affixing the artery to the dura over the petrous bone was used to keep it away from CN VII (*Fig. 3*). The same procedure was used to keep a high looping anteroinferior cerebellar artery (AICA) away from CN V in patients with TGN. In the patient with disabling tinnitus, an AICA loop was compressing CN VIII, which was decompressed by placing a Teflon felt (*Fig. 4*).

Postoperatively, all patients with TGN in whom endoscope was used experienced complete relief of symptoms, and these patients are no longer receiving medication. None of the patients with TGN experienced symptomatic hearing loss postoperatively, and an audiogram was not performed. One patient with HFS continued to have occasional facial spasm for a period of approximately 3 weeks after MVD; the spasms gradually resolved completely. A postoperative audiogram was performed in all patients who underwent MVD of CNs VII or VIII and did not reveal hearing loss.

No complications were encountered in these patients related to the use of the endoscope. Five patients with TGN developed mild and transient ipsilateral facial sensory deficit postoperatively, and this resolved completely. One patient with HFS developed a House-Brackmann Grade 2 ipsilateral facial weakness postoperatively; this weakness continued for 3 months and gradually resolved completely. No other complications related to surgery were noted during the follow-up period.

The follow-up period ranged from 6 to 52 months. We categorized all patients into four different groups on the basis of their follow-up periods. Six patients were followed for 6 to 12 months, 2 patients were followed for 13 to 24 months, 11 patients were followed for 25 to 36 months, and 9 patients were followed for 37 to 52 months. The mean follow-up period was 29 months, with a median of 40 months.

DISCUSSION

Neuroendoscopy seems to be a useful adjunct to microneurosurgery for the treatment of aneurysms and for MVD operations (1, 13, 16, 19). Its usefulness has been documented in operative approaches to aneurysms (15), and its role in cerebellopontine angle exploration has been reported (6, 19, 20). We emphasize that the microscope and endoscope play a synergistic role and complement each other in MVD of CNs V, VII, and VIII, without the endoscope having the primary role and replacing the microscope.

Endoscope-assisted MVD

MVD of the involved CN has a major role in the treatment TGN and HFS, as well as other CN compressive syndromes

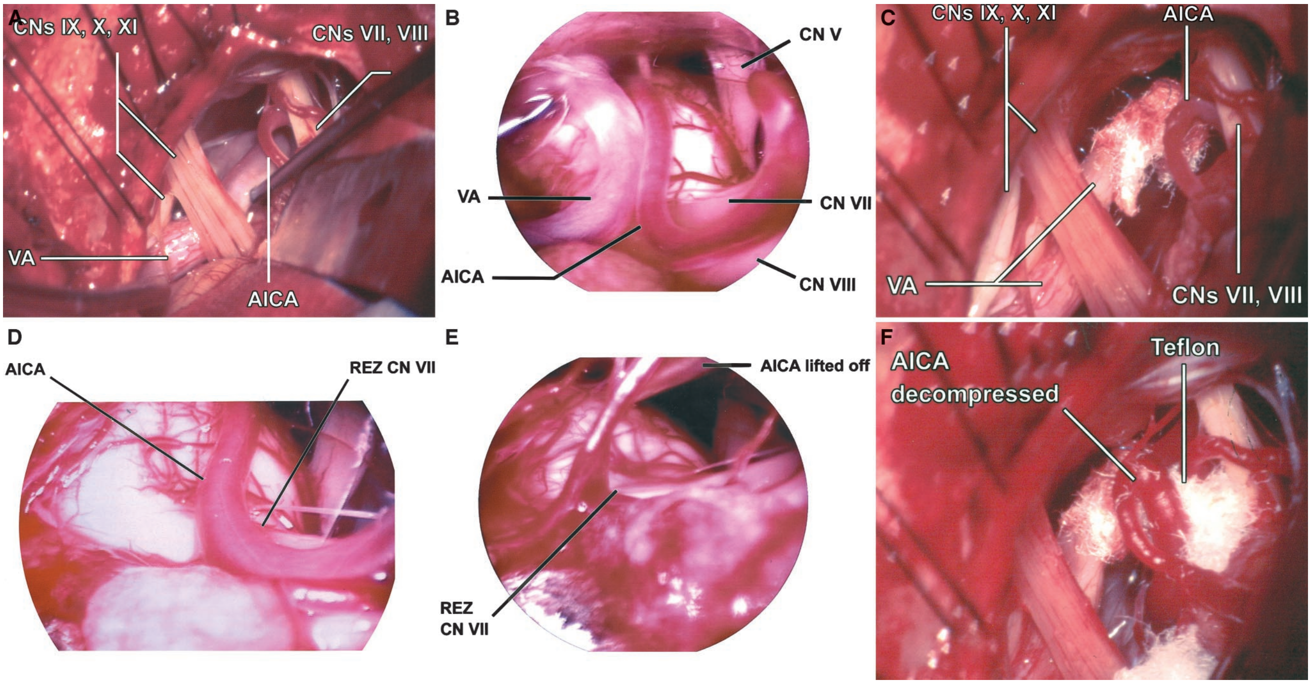

FIGURE 2. *Successive microscopic and endoscopic views in a case of endoscope-assisted MVD of CN VII for HFS.* A, *microscopic view of the posterior fossa of the patient.* B, *endoscopic view showing compression of CN VII by the VA and AICA at the REZ.* C, *microscopic view after decompression of the VA by using Teflon felt.* D, *endoscopic view showing the AICA still compressing CN VII at the REZ after decompression of the VA.* E, *endoscopic view showing complete decompression of CN VII at the REZ after the AICA is lifted off by pexy procedure.* F, *final microscopic view showing placement of Teflon felt between CN VII and the AICA.*

(7–11, 21, 23). Negative exploration has been reported in approximately 1 to 2% in large series and is higher in smaller series. Incorrect diagnosis of TGN and the possibility of multiple sclerosis must be also kept in mind (11). However, the decrease of negative exploration with experience suggests that nonvisualization of nerve-vessel contacts is one of the factors in negative exploration and the failure of this procedure.

A large TGV compressing CN V and draining into the MC area is a well-known finding and may be missed if not specially looked for (4, 11). In our series, the presence of a bony ridge prevented the adequate observation of this site by microvision. The endoscope was very useful to view this area. Inspection of the first 2 to 3 mm of CNs V and VII near the brainstem and of the inferior and anterior surfaces of CN V was also greatly aided by the endoscope. At the end of the MVD, the endoscope was very useful to ensure adequate decompression of the involved CN. After reviewing the largest series to date of patients undergoing MVD for TGN, Lovely and Jannetta (18) recommended that all vessels, regardless of size and location, should be decompressed.

Our study supports the routine use of the endoscope along with the microscope to look systematically at all areas of possible compression. In a study of endoscopy in TGN, Jarrahy et al. (12) concluded that it was useful to confirm nerve-vessel contacts, to reveal other vessels that had escaped microscopic survey, and to assess the adequacy of decompression. Other CN compression syndromes, such as disabling positional vertigo or tinnitus and glossopharyngeal neuralgia, may also benefit from endoscope-assisted MVD because nerve-vessel contacts are found in many of these cases (6, 16). The neuroendoscope, used along with the microscope, may have decreased the need for rhizotomy and improved the success rate in large reported series (7, 18). High-resolution magnetic resonance imaging with 1-mm slices may reveal these nerve-vessel relationships preoperatively in patients with a clinical diagnosis of TGN (3). Our study suggests that these missed contacts are usually venous in nature and tend to occur distally near MC for TGN; small venous or arterial compression may also be missed in HFS patients. Also, it is clear in our patient series that multiple vessel contacts were the most common type of vascular compression found when the endoscope was used. In patients with HFS and disabling positional vertigo or tinnitus, inspection of the REZ of CN VIII without lateral to medial retraction of the cerebellum is easily possible with the endoscope, lessens the chances of CN VIII traction, and minimizes cerebellar retraction (16). For patients with HFS, monitoring of lateral spread is useful to ensure adequate decompression (17). The endoscope is also used to look for vascular compression inside the internal auditory canal in patients with disabling positional vertigo or tinnitus

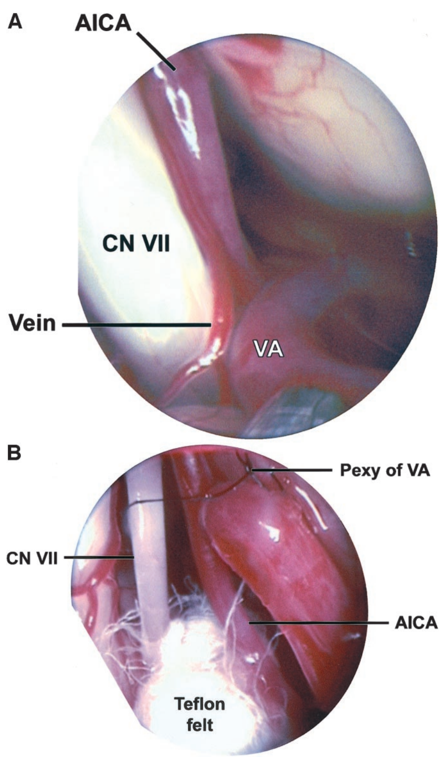

FIGURE 3. A, *the AICA and a small vein compressing the right CN VII.* B, *Teflon felt is placed between the right CN VII and AICA loop. Pexy of the VA is performed with an 8-0 nylon stitch.*

because the centrally myelinated portion of CN VIII extends well into the internal auditory canal.

The advantages and disadvantages of the endoscope versus the microscope have been well discussed by King et al. (16). The main advantages of the endoscope are that it shows the center of the operative field unaffected by the size or depth of the field itself. The higher magnification helps to achieve a clear visualization of blood vessels and nerves and thus is critical for assessment of the cerebellopontine angle. Its ability to look around corners and behind anatomic structures, which is not possible with a microscope, has special relevance in MVD.

Several problems associated with the use of the endoscope in the subarachnoid space and cranial base should be mentioned. The first is that the endoscope provides vision only at its tip. The inability of the endoscope to look sideways or backward when positioned in the operative field and the possibility of injury to adjacent structures by the shaft of the endoscope means that any movement has to be performed only under microscope vision. The problem is compounded because endoscopic images are two-dimensional and lack a sense of depth. Keeping an eye on both the microscopic and endoscopic surgical fields at all times is crucial but difficult, even with the present systems of image fusion technology.

Second, holding devices for the endoscope are still inadequate, especially for use in the narrow confines of the subarachnoid space (14). The surgeon often has to hold it in one hand, thereby limiting himself or herself to working with the other hand. Third, there is still a lack of microinstruments specifically designed for use under endoscopic vision in the subarachnoid space. Basically, the ability to see is not matched by the ability to do something about what is seen. Last, even a mild discoloration of the cerebrospinal fluid by blood drastically reduces the quality of the endoscopic images and renders them useless. Thus, developments in image fusion technology, instrumentation, holding devices, antifogging devices, and irrigation devices are all necessary to improve the usefulness of the endoscope.

Because the three-dimensional view afforded by the microscope is important during MVD in addition to the two-dimensional view afforded by the endoscope, and because of the concern about injuries to other CNs during MVD by the

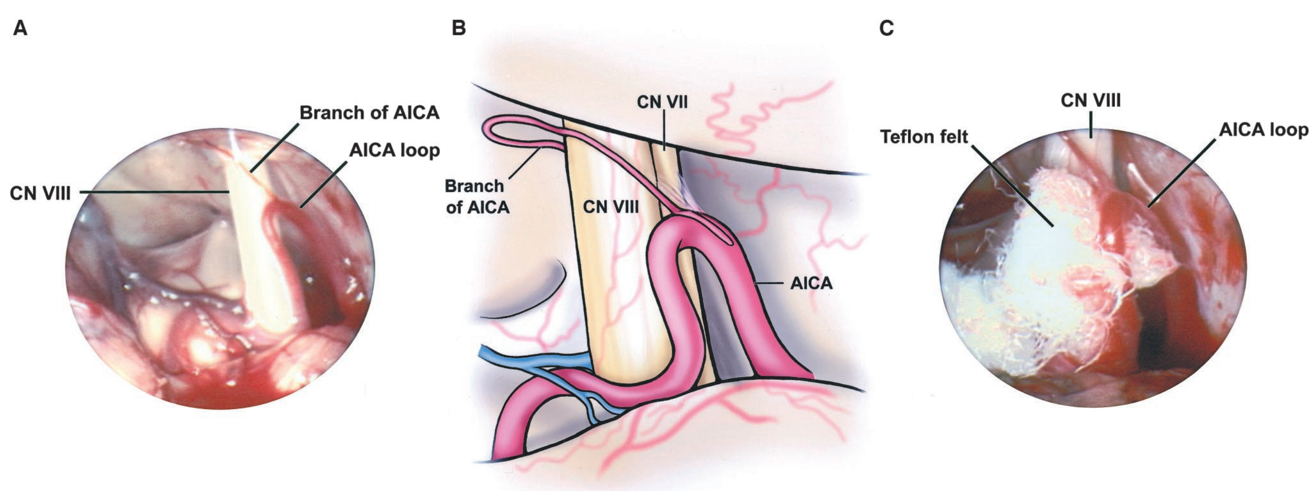

FIGURE 4. A, *AICA loop compressing CN VIII in a patient with disabling tinnitus.* B, *schematic drawing of the same endoscopic view.* C, *Teflon felt has been placed between the AICA loop and CN VIII.*

endoscope (which is blind on the sides, except at its tip), the senior author still prefers endoscope-assisted MVD to MVD performed entirely with the endoscope. Of the various available types of fusion of microscopic and endoscopic images, none is completely satisfactory at present.

CONCLUSION

Neuroendoscopy may have a valuable role in MVD of CNs V, VII, and VIII in patients with TGN, hemifacial spasm, and disabling positional vertigo and should be considered as an adjunct to the microscope in treating these patients. It may also be very useful in other CN compression syndromes. There are many advantages to its use, but it also has some disadvantages that need to be addressed to make it even more useful and easier to use. In general, it allows better viewing with less retraction. The main disadvantage is that structures can be visualized easily, but surgeons cannot work entirely under endovision.

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COMMENTS

Rak et al. demonstrate here that a picture is worth a thousand words: their useful figures provide numerous examples of the powerful role endoscopy can play as an adjunct to the operating microscope in surgery for microvascular compression syndromes. The endoscope allows the surgeon to look around corners and see structures that are out of the line of sight of the microscope. The authors have provided a thoughtful, balanced discussion of the advantages and disadvantages of the use of the neuroendoscope in the subarachnoid space during cranial base surgery. As image fusion technology improves and gives us the ability to have picture-in-picture visualization of both microscopic and endoscopic images through a single set of oculars, endoscope-assisted microneurosurgery will be become increasingly popular. The addition of endoscopic visualization should lead to fewer negative explorations in microvascular decompression (MVD) surgery.

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Rak et al. have described their experience with endoscope-assisted techniques for treating microvascular compression syndromes. The senior author (LNS) performed MVD in 28 patients with excellent results; all patients experienced improvement of their symptoms without postoperative complications. After performing so-called standard craniotomies (*Fig. 2A* in the article), the endoscope was used in every procedure as an important tool in most of the cases for additional visualization and in seven cases for procedure assistance. The authors concluded that the endoscope was a very useful adjunct without a primary role during surgery.

In our department, we perform MVD in every case with endoscope-assisted techniques; however, according to our technique, endoscopic visualization has an absolutely primary role during surgery. Because we use keyhole approaches with a dural opening of less than 1 cm, visualization with the surgical microscope is limited as a result of the enormous loss of light intensity in the deep surgical field. In these cases, adequate observation of the compressing vessels is almost impossible without the endoscope. For those with experience in paraendoscopic dissection, the two-dimensional image of endoscopes is not disturbing; on the contrary, rod lens scopes permit a large field of view and well-focused structures, which results in a more three-dimensional experience than binocular microscopes.

Endoscope-holding devices and conventional microinstruments are often inadequate for use in endoscope-assisted surgery; however, the new generation of pneumatic holding arms, the angled design of endoscopes developed for endoscope-assisted techniques, and the tube shaft construction of new microinstruments allow safe paraendoscopic dissection within narrow anatomic structures. Our experience shows that the endoscope not only allows excellent visualization of pathoanatomic structures but also permits safe and complete surgery entirely under endovision, especially when MVD is performed.

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The use of the endoscope as an adjunct to conventional microsurgery has gained increasing importance during the past decade. Rak et al. convincingly report the usefulness of endoscope-assisted MVD of the trigeminal root in 17 patients, the facial nerve in 10 patients, and the vestibulocochlear nerve in 1 patient. All of the patients were asymptomatic and were not receiving medication at the time of the follow-up examination. One of the major benefits of such a combined technique is that the endoscope allows visualization of offending vessels that cannot be seen with the microscope alone during surgery for trigeminal neuralgia (TGN) and hemifacial spasm. After having gained experience with this technique during a 3-year period, the authors now emphasize the synergistic roles of the microscope and endoscope in the surgical treatment of TGN, hemifacial spasm, and disabling positional vertigo or tinnitus.

On the other hand, because manipulation through the endoscope alone is difficult, the authors do not consider the endoscope a primary tool that could replace the microscope. Despite the frequent use of the endoscope in our department, we have not applied the endoscope-assisted microsurgical technique in MVD procedures because there was no necessity for doing so. For instance, we have not encountered the same difficulties in visualizing the entrance of the trigeminal root into Meckel's cave, as the authors did in their series. The bony ridge posterior to the trigeminal nerve (presumably the suprameatal tubercle), mentioned by Rak et al. as obscuring the microscopic view of this area in some of their patients, may be a significant obstacle only when the viewing trajectory of the microscope is lateral to medial. We routinely choose a more medial viewing angle by exposing the trigeminal root exclusively from a supracerebellar route. In the patients we have treated microsurgically to date with this approach, the suprameatal tubercle does not hamper the visualization of the distal trigeminal root. We agree, though, that inspecting an area behind certain anatomic structures, such as the route entry zone of Cranial Nerve VIII, may be achieved with less retraction with the endoscope.

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Rak et al. used the endoscope in 17 patients with TGN, 10 patients with hemifacial spasm, and 1 patient with disabling tinnitus as an adjunct to the operating microscope during MVD. They found no vascular compression in 2 (11.7%) of 17 patients, a figure that is not lower than those of other studies performed without the endoscope. The authors also found either the trigeminal vein or petrosal vein branches to be the only compressing structures (alone or with a dural band in one case) in 5 (29.4%) of their 17 TGN patients. In a major study of MVD without endoscopy, Barker et al. (1) found a vein in only 151 (13%) of 1204 patients and an unspecified small artery or vein only in 223 (19%) of 1204 patients. Rak et al. found compression of the trigeminal nerve by the superior cerebellar artery in 8 (47%) of 17 patients and by the anteroinferior cerebellar artery in 1 (6%) of 17 patients, whereas Barker et al. found compression of these arteries in 75 and 10% of patients, respectively.

In two patients, Rak et al. found venous compression of the trigeminal nerve near Meckel's cave that was visualized only endoscopically and was missed when the microscope was used alone. Venous compression of the trigeminal nerve is a less important cause of TGN than is arterial compression. One of the factors predicting long-term relief from TGN after MVD was absence of venous compression of the trigeminal root entry zone (1).

Rak et al. performed MVD of the trigeminal nerve in six patients by cauterizing and dividing the trigeminal vein at Meckel's cave; this treatment of veins is the classic recommendation. A recent study showed that magnetic resonance imaging evidence of pontine infarction was present in 24% of patients who had undergone MVD (2). It was suggested that some of these cases might represent venous infarction from coagulation of small venules during exposure of the root entry zone. In part because of this, some experienced neurosurgeons have been reluctant to divide veins, especially large ones, during MVD. Shredded Teflon felt is used to separate the nerve from some of these larger veins, which may be partially cauterized. How effective this will be compared with cauterization and division of the vein remains to be assessed.

The ultimate test of a new procedure for cranial nerve compressive syndromes is how effective it is in relieving symptoms, and what kind of risks it presents. Although the data of Rak et al. are promising in this regard, they must be viewed as preliminary because relatively few patients are reported, and the follow-up period is short or intermediate. The cerebellopontine angle is a small place with the potential for added risks associated with endoscopy. These risks have to be considered, especially when we already have proven techniques that relieve the pain of TGN in many patients with minimal risk.

Visualization at the time of surgery for MVD is important for successfully performing the procedure. The improved illumination and magnification of the operating microscope have established this operation as valid and important for treating patients with these syndromes, especially when treatment by less invasive methods has not been successful. The authors clearly set out the rationale for the use of endoscopy as a tool to improve the visualization provided by the operating microscope and report data to substantiate its role. It is important for neurosurgeons to be aware of this experience and to consider the possible use of endoscopy in these patients. Only time, further reports on more patients by these and other investigators, longer follow-up, and refinements of technique will clarify the role of endoscope-assisted microsurgery for MVD.

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1. Barker FG, Jannetta PJ, Bissonette DJ, Larkins MV, Jho HD: The long-term outcome of microvascular decompression for trigeminal neuralgia. **N Engl J Med** 334:1077–1083, 1996.
2. Jawahar A, Kondziolka D, Kanal E, Bissonette DJ, Lunsford D: Imaging the trigeminal nerve and pons before and after surgical intervention for trigeminal neuralgia. **Neurosurgery** 48:101–110, 2001.

The CAE-Link Helmet Mounted Display (HMD), an early 1990s model for use in aviation instruction, is shown here; it enables bright, high-resolution, full-color computer-generated imagery to be projected over an unlimited field of vision. HMDs are specifically designed to duplicate the operation and performance of the human eye. By monitoring the direction the wearer is looking, imagery is generated that covers the line of sight. HMD displays can easily be combined with other sensor simulations such as Forward Looking Infrared (FLIR) devices, for example. See also pages 1037 and 1041. (Courtesy, CAE-Link Corp.)