Simultaneous microscopic and endoscopic monitoring during surgery for internal carotid artery aneurysms

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Object. The authors of this study evaluated the efficacy of simultaneous microscopic and endoscopic monitoring during surgery for internal carotid artery (ICA) aneurysms.

Methods. The endoscopic technique was applied during microsurgery in 11 patients with 13 aneurysms. Nine of these lesions were located on the posterior communicating artery (PCoA), three in the paracanoid region, and one on the anterior choroidal artery (AChA). Eight patients had unruptured aneurysms and three had ruptured aneurysms. The endoscope was introduced after first exposing the aneurysm through the microscope and was gripped firmly by an air-locked holding arm fitted with a steering system throughout the entire surgery, including dissection of the perforating arteries and application of the aneurysm clips.

Regarding paracanoid aneurysms, clips were applied through direct visualization of the ophthalmic artery and the proximal neck. In a case involving a superior hypophyseal artery aneurysm in the paracanoid segment, a ring clip was applied without removing the bone structure around the optic canal. In all aneurysms of the PCoA and the AChA, perforating arteries behind the lesion were identified and dissected using endoscopic control. The aneurysm clip was applied in the best position in a single attempt in 10 of 11 patients. There was no surgical complication related to the endoscopic procedures.

Conclusions: Simultaneous monitoring with the microscope and endoscope is extremely useful in applying clips to ICA aneurysms. This combined method allows for direct dissection of the aneurysm, perforating vessels, and the main trunk in an area not visible through the microscope’s eyepiece and promises better surgical results.

Key Words: clip application • endoscope • intracranial aneurysm • microsurgery • minimally invasive surgery

Posterior communicating artery and AChA aneurysms are the two types of major trunk aneurysms located in the supracanoid segment of the intracranial ICA. Treatment of these lesions requires preservation of the PCoA, AChA, and perforating arteries to avoid morbidity. Aneurysms in the paracanoid segment of the ICA are located at either branching sites, such as the OphA and the superior hypophyseal artery, or nonbranching sites, such as the ventral paracanoid region and the carotid cave, and usually arise from the medial/posterior aspect of the ICA. Therefore, the microscopic view of the aneurysms is obstructed by the ICA, optic nerve, and bone structures including the anterior clinoid process. Some of these aneurysms are inappropriate for clip application, or surgical treatment would result in disastrous outcomes because of the location of the aneurysm. Various surgical techniques and microanatomical studies have been tried to develop neurosurgical procedures for improved intervention. Recently, endoscopes have been used in microsurgery for intracranial aneurysms. Advances in optical instruments now allow clear vision through small-caliber endoscopes, which can be introduced into narrow and deep brain regions to observe hidden anatomical relationships around aneurysms located on the side of the artery opposite to the microscopic view.

In this report we describe our techniques for the treatment of ICA aneurysms through simultaneous monitoring with a surgical microscope and an endoscope gripped by an air-locked holding arm and fitted with a steering system.

Clinical Material and Methods

Patient Population

Ninety-six patients underwent surgery for aneurysms situated in 128 sites between January 2001 and July 2003. An endoscope was used in 33 cases. Continuous endoscopic monitoring data were available for 13 aneurysms in 11 patients—four men and seven women whose ages ranged from 41 to 74 years (mean 55.9 years). Nine aneurysms were located on the PCoA, three in the paracanoid region.

Abbreviations used in this paper: AChA = anterior choroidal artery; CA = carotid artery; ICA = internal CA; OphA = ophthalmic artery; PCoA = posterior communicating artery.
Endoscopic Instrumentation

Two types of rigid endoscopes with a 30 or 70° viewing angle, 2.7-mm outer diameter, and 225-mm length (Olympus Optical Co., Tokyo, Japan) were used. The endoscope was gripped by a holding arm fixed to the operating table to allow the surgeon to perform microsurgical manipulation with both hands while simultaneously using endoscopic and microscopic monitoring as described by Perneczky and Fries. The holding system was based on retractor arms (Olympus Optical Co.) in the initial six cases, and an air-locked holding arm (Unitrak; B. Braun Aesculap Japan, Tokyo, Japan) with an endoscope steering system (Neuropilot; B. Braun Aesculap Japan) in the other five cases. Illumination was provided by a xenon light source. The video units for endoscopy consisted of an L-shaped camera adaptor (AR-TL12S; Olympus Optical Co.), a three-tipped camera (Olympus Optical Co.), a videotape recorder (Sony Corp., Tokyo, Japan), and a 19-in video monitor (Sony Corp.). The video monitor displaying the endoscopic view was placed in front of the surgeon.

Surgical Procedure

The craniotomy, subarachnoid dissection, and cranial base osteotomies were performed in the usual manner. If the entire aneurysm wall could not be visualized through the microscope after exposing the aneurysm neck and sac, the rigid endoscope was manually introduced with the aid of the microscope. If the endoscope showed new information and surgical manipulation was necessary to accomplish clip application, then the endoscope was introduced into the prechiasmatic cistern or between the optic nerve and the ICA and was fixed in place with the holding system. In the last five cases, the endoscope was first introduced to a point some distance from the optic nerve or the ICA and then the holding arm (Unitrak) was secured with the air-lock. The three dials of the fine steering system (Neuropilot) were then used to move the tip to the required position gradually, without traumatizing any vessel or neural tissue. This system is well organized to integrate the endoscope into microsurgery for aneurysms. After inspecting the entire aneurysm wall and confirming the rupture point in cases of subarachnoid hemorrhage, the perforating arteries behind the aneurysm sac were dissected with the aid of simultaneous microscopic and endoscopic monitoring. In the case of paraclinoid aneurysms requiring cranial base osteotomies, including unroofing the optic canal and/or removing the an-

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terior clinoid process, the endoscope was removed temporarily during drilling.

Results

All 13 aneurysms were eliminated by clip application. All patients recovered well after surgery with excellent or good outcomes (Glasgow Outcome Scale Score 5 or 4). No morbidity was related to the use of the endoscope.

Clip application was completed in a single attempt in 10 cases, and clip repositioning was required in only one case. The clip was applied to three paraclinoid aneurysms with direct visualization of the OphA and/or the superior hypophyseal artery through the endoscope. A ring clip was positioned using endoscopic guidance without removal of the anterior clinoid process in one patient. The perforating arteries hidden from microscopic view in all nine cases of PCoA aneurysms were dissected free from the aneurysm sac with the aid of the endoscope. The multiple clip application technique was performed in two patients with a blood blister–like aneurysm on the anterior wall of the ICA and a large PCoA aneurysm. The magnified and illuminated view through the endoscope allowed tandem clip placement without repositioning. In the case of an AChA aneurysm, continuous endoscopic monitoring was performed to explore occlusion of the perforating arteries, which looked patent soon after clip application. The clip was then repositioned to avoid stenosis of the perforating arteries. It was applied to the best position in a single attempt in all other cases, thus avoiding encasement of the perforating arteries.

Illustrative Cases

Case 1

This 60-year-old woman was referred from another hospital with the diagnosis of an unruptured right ICA–OphA aneurysm after examination for headache (Fig. 1A). A right pterional craniotomy was performed to clip the aneurysm after exposing the ICA in the patient’s neck. The aneurysm was dissected from the optic nerve completely and was obliterated using double clips, paying careful attention to the OphA through combined microscopic and endoscopic monitoring (Fig. 1B–H).

Case 2

This 64-year-old man presented with a slight headache following head trauma. He was referred from another hospital with an unruptured right PCoA aneurysm, which had been diagnosed based on magnetic resonance imaging studies. Results of angiography showed a large left PCoA aneurysm arising posteriorly from the ICA (Fig. 2A). A left pterional craniotomy was performed to clip the aneurysm. The endoscopic view revealed that several perforating arteries of the PCoA had adhered to the medial wall of the aneurysm (Fig. 2C), and these perforating arteries were dissected from the aneurysm sac while observing the endoscope monitor (Fig. 2D). Thereafter, oxycellulose was inserted between the aneurysm sac and the surrounding perforating arteries to make adequate space for the clip blades, and then multiple clips were applied to the aneurysm through continuous microscopic and endoscopic monitoring (Fig. 2E–L).

Case 3

This 74-year-old woman was transferred from another hospital 48 hours after the onset of subarachnoid hemorrhage (Hunt and Hess Grade II). Angiography studies revealed a left PCoA aneurysm (Fig. 3A). Surgery was performed via a left pterional approach on the same day. The view through the endoscope introduced between the optic nerve and the ICA demonstrated that the perforating arteries of the PCoA were adhered to the proximal neck of the aneurysm. Therefore, the perforating arteries and the proximal neck were dissected and a clip was applied, thus avoiding occlusion of the arteries with the aid of continuous microscopic and endoscopic monitoring in a single trial (Fig. 3B–H).

Case 4

This 54-year-old woman was referred from another hospital with a diagnosis of an unruptured right ICA aneurysm, which had been based on magnetic resonance imaging. Angiography demonstrated a left AChA aneurysm oriented posteriorly (Fig. 4A). The patient underwent clip application of an aneurysm neck via a left pterional craniotomy. Endoscopic monitoring revealed delayed occlusion of the perforating arteries of the AChA following clip application, and therefore the clip was repositioned to restore blood flow to the perforating arteries (Fig. 4B–H).

Discussion

Rationale for Simultaneous Microscopic and Endoscopic Monitoring

Recently, the introduction of the endoscope in microsurgery for cerebral aneurysms has been advocated because of the view around corners and areas hidden from the microscopic field. Perneckzy and Fries elaborated on the general principles of endoscope-assisted microsurgery and described three advantages of endoscopes: increased light intensity while approaching an object, clear depiction of details in close-up positions, and extended viewing angle. Initially, they presented the concept of endoscope-assisted microneurosurgery with combined microscopic and endoscopic control. The position and fixation of the endoscope are achieved by retractor arms fixed to the operating table or the headrest. Thus, the surgeon can perform microsurgical manipulations with both hands while maintaining simultaneous endoscopic and microscopic control at all times to inspect hidden structures, dissect perforating arteries behind an aneurysm, identify important vessel segments without retraction of the aneurysm or arteries, and check for completion of clip application.

Advantages of Simultaneous Microscopic and Endoscopic Monitoring

The advantages of simultaneous microscopic and endoscopic monitoring in aneurysm surgery have been described in general. In this study, we advocated the use of simultaneous monitoring in ICA aneurysm surgery because of these technical advantages, which are demonstrated on serial intraoperative endoscopic pictures. Data from the present study clearly demonstrated the benefit of this technique.
through the integration of the simultaneous visual information.

Although aneurysms in the paraclinoid segment of the ICA can be visualized without removing the anterior clinoid process—depending on the aneurysm location—clip maneuvering and preservation of the CAs and OphAs usually require removal of bone structures. Nevertheless, some of these lesions can be clipped without resection of the anterior clinoid process if attention is paid to the parent arteries. As we indicated earlier, the superior hypophyseal artery aneurysm, which was completely invisible through the microscope’s eyepiece, could be obliterated using a ring clip without removal of the bone structures and using both monitoring devices.9

For supraclinoid aneurysms, the major benefit was visualization of the perforating arteries behind the aneurysm. Although aneurysms with posterior projection had adhered to these arteries, the lesion neck on the PCoA could be dissected from them, thus providing adequate space for clip application. Oxycellulose proved very useful to separate the

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perforating arteries from a large aneurysm sac, allowing ample space for insertion of a clip blade along the proximal portion of the PCoA for reconstruction. This dissection technique seemed impossible without the continuous visualization provided by the fixed endoscope.

Simultaneous visual control was also valuable in applying a ring clip, especially when using the multiple clip technique. Another advantage of continuous endoscopic monitoring while applying an aneurysm clip is the ability to confirm the position of the perforating arteries throughout the entire procedure. Because we could observe these arteries directly without interruption before, during, and after the clip procedure, optimal clip application could be achieved in a single attempt. Except in the patient in Case 4, all aneurysm clips were placed in the optimal position without the need for repositioning because placement was confirmed directly under continuous combined visual monitoring. In the patient in Case 4, continuous direct visualization of the perforating arteries behind the aneurysm revealed the late occurrence of occlusion caused by a tight clip or distortion of the clip. Repositioning was successful.

Although the multiple clip technique was used in only two cases in this study, clip applications were successful on the first attempt. In previous studies, 9.3 to 12.7% of aneurysms treated using endoscope-assisted microsurgery required repeated clip application based on new information—such as incomplete neck obliteration, clip involvement with the perforating arteries, or compression of neural tissue—provided through the endoscope that had been introduced after clip placement. Therefore, simultaneous endoscopic and microscopic monitoring compared with the intermittent use of the endoscope in aneurysm microsurgery reduces the risk caused by clip placement in regions not visible in the microscopic field.

**Holding-Arm System**

The main drawbacks of endoscope-assisted aneurysm surgery are as follows: 1) The endoscope is a tool similar to any dissection instrument used very close to the aneurysm or neural tissue; that is, it can cause rupture of the aneurysm and/or neural tissue damage. 2) The endoscopic view is two-dimensional, highly magnified, extremely distorted, and not easy to reconstruct with three-dimensional anatomy in mind. 3) When there is blood in the surgical field, the endoscope is useless. 4) Instrumentation specifically designed for endoscopic surgery is not yet available. Note that trauma should be prevented by all means possible. In this regard, the holding-arm system plays a key role in avoiding complications as well as accomplishing the surgery. A slight movement of the endoscope in a deep and narrow space might cause serious injury to surrounding vas-
cular and neural tissue. Even recently, some authors have preferred to hold the endoscope manually because available holding devices are bulky, thus obstructing the surgical field and increasing the risk of inadvertent movement of the endoscope tip close to the aneurysm.

The holding system adopted in the last five cases in our study consisted of a combination of an air-locked holding arm (Unitrak) and an endoscopic steering system used as a micromanipulator (Neuropilot)—the latter component having been only recently developed. This holding system with its multiple joints can be fixed by the release of a button. The steering system can provide fine three-dimensional movement. The endoscope has a total length of 225 mm and its inserted portion is 158 to 161 mm in length. Its end portion (64–67 mm) was connected to a xenon light source and a camera. The Neuropilot holds the endoscope between the inserted and end portions. Thus, if we inserted the endoscope through the edge of the craniotomy, it did not usually disturb the position of the microscope. In addition, the L-shaped camera adaptor connecting the endoscope end with the three-tipped camera played a pivotal role in avoiding interference with the microscope’s position.

We introduced the endoscope from the medial bone edge to a point some distance from the final destination and released the button for the air lock. Once the holding arm is locked, it will not move inadvertently. The three dials of the Neuropilot steering system were turned to move the tip of the endoscope to its final position in either the prechiasmatic cistern or the carotid-optico triangle (between the ICA and the optic nerve) to obtain the optimal view. With this steering system, the position of the endoscope can be adjusted to obtain the optimal view corresponding to the movement of the aneurysm during clip application without unlocking the holding arm itself. Therefore, it even enabled an assistant to correct the endoscope’s position by turning the Neuropilot dials at the request of the operator whose hands were involved in placing the clip. This fine movement of the endoscope with the holding arm locked could not be achieved with the previous holding system without interrupting surgery.

After confirmation of clip placement, the endoscope was withdrawn from the brain tissue by using the steering system, the air-lock button was released, and the endoscope was removed from the bone window with the aid of microscopic control.

In this study, no morbidity was related to the endoscope technique. Therefore, we recommend the simultaneous use of microscopic and endoscopic monitoring with the Unitrak and Neuropilot holding system for the treatment of aneurysms, especially ICA aneurysms.

Conclusions

Simultaneous endoscopic and microscopic guidance was used successfully to place aneurysm clips on the suprachiasmatic and paracolinal ICA with no morbidity in the patient.
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This method could provide important information hidden from the microscopic field and monitor the working environment with continuous direct visualization.

References


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