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Intracranial-to-intracranial vascular anastomosis created using a microanastomotic device for the treatment of distal middle cerebral artery aneurysms

Technical note

**DAVID W. NEWELL, M.D., JAMES M. SCHUSTER, M.D., PH.D.,
AND ANTHONY M. AVELLINO, M.D.**

Department of Neurological Surgery, University of Washington School of Medicine and Harborview Medical Center, Seattle, Washington

✓ The use of a microanastomotic device for direct connection of intracranial vessels can be helpful to facilitate removal of distally located middle cerebral artery (MCA) aneurysms. The authors report on two patients who presented for treatment with large aneurysms distally located on the MCA. The aneurysms were completely excised and the proximal and distal portions of the parent vessel were connected in an end-to-end fashion by using a microanastomotic device. The time required to crossclamp the vessel for excision of the aneurysm and primary anastomosis was 10 minutes in one case and 15 minutes in the other. The short crossclamp time and high-quality anastomosis afforded by this device may be useful in the treatment of these difficult lesions and the prevention of cerebral ischemia.

KEY WORDS • microanastomotic system • middle cerebral artery aneurysm • intracranial anastomosis • giant aneurysm • fusiform aneurysm

LARGE, giant, or fusiform intracranial aneurysms can provide a challenge to neurosurgical treatment because sometimes they are not suitable for direct clipping or treatment by interventional methods. When large or giant saccular or fusiform aneurysms occur in the MCA, as well as in other locations, they can incorporate the parent and distal vessels and often are difficult to obliterate without compromising blood flow. Various treatments have been advocated, including external wrapping and reinforcement, proximal ligation with vessel sacrifice, clip reconstruction, proximal vessel ligation augmented by EC–IC bypass, or excision with intracranial interpositional grafting.[1,3,5,7,10,13] The treatment goals should be to eliminate the aneurysm from the circulation and preserve flow to the distal vasculature.

In patients harboring these aneurysms often there may be an intact collateral circulation to the distal vasculature, allowing parent vessel sacrifice without ischemic complications. Unfortunately, it may be difficult to predict which patients will tolerate vessel occlusion. In certain instances, a test occlusion may be performed to predict whether parent vessel sacrifice may be tolerated; however, the role of this test has not been established.[5] Ideally, treatment of the aneurysm should allow blood flow to be provided to the distal vasculature if technically feasible with minimal risk. This may be accomplished by excision of the aneurysm accomplished by an EC–IC bypass procedure performed using sutures to create the anastomosis[6] or, alternatively, by an IC–IC bypass, which also has been described.[8]

We report two cases in which distally located MCA aneurysms incorporated the parent vessel. The aneurysms were treated using primary aneurysm excision accompanied by surgical anastomosis of the proximal and distal portions of the vessel, which was performed with the aid of a vascular microanastomotic device (The Coupler; Medical Companies Alliance, Birmingham, AL).

Illustrative Cases

Case 1

History and Examination. This 60-year-old woman presented with a history of a syncopal episode. Imaging studies identified a large fusiform aneurysm on the distal MCA. The cause of the patient's syncope was not determined. Her family history was significant because two first-degree relatives had previously suffered subarachnoid hemorrhage. The patient chose to undergo elective surgical repair of the aneurysm.

Cerebral angiograms and a CT angiogram revealed a large fusiform aneurysm in the right MCA (Fig. 1). The

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Abbreviations used in this paper: CT = computerized tomography; EC–IC = extracranial-to-intracranial; IC–IC = intracranial-to-intracranial; MCA = middle cerebral artery; STA = superficial temporal artery.

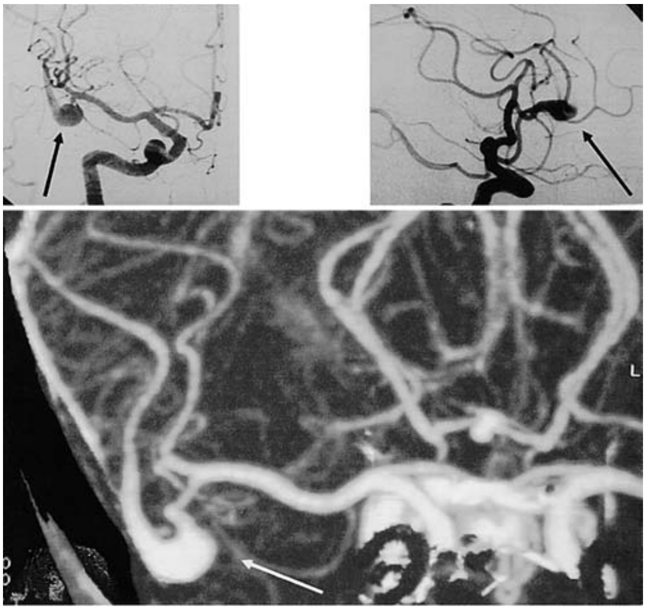

FIG. 1. Case 1. *Upper:* Angiograms demonstrating anteroposterior *(left)* and lateral *(right)* views of the right MCA fusiform aneurysm *(arrows)* with its origin just distal to the MCA trifurcation. The distal portion of vessel continues into the posterior aspect of the sylvian fissure. *Lower:* Three-dimensional reconstruction of a CT angiogram detailing the anatomy of the aneurysm *(arrow)*.

aneurysm arose from one of the three main branches of the MCA trifurcation and extended into the sylvian fissure. There was significant blood flow into the distal vasculature from the vessel that emanated from the aneurysm.

Operation. A right frontal temporal craniotomy was performed to expose the aneurysm. The scalp dissection was designed to dissect out the STA for possible use as a bypass graft combined with proximal ligation of the aneurysm. The parietal and frontal branches of the STA were dissected out and irrigated with heparinized saline, after which temporary clips were placed across the divided ends. After the dura mater had been opened, a large fusiform aneurysm covered with arachnoid mater was directly visualized in the sylvian fissure (Figs. 2 and 3). The aneurysm was dissected out and the proximal arterial branch was found to arise from the MCA trifurcation. A portion of the vessel was enlarged and led into a large fusiform aneurysm, which was serpentine in nature and was contained within the sylvian fissure. Due to the tortuosity of the vessel, the distal branch emanating from the aneurysm was close to its proximal origin from the trifurcation.

The patient was cooled slightly to 34˚C and her blood pressure was maintained above a systolic pressure of 140 mm Hg. Temporary clips were placed on the proximal and distal portions of the vessel and the aneurysm was excised. A small remnant of the diseased portion of vessel was left on each end of the dissection. These ends were loaded into the 2-mm ring of the microanastomotic device by using a jeweler forceps and a Pierce ring-end forceps. The anastomotic procedure was then completed and the temporary clips were removed 10 minutes after their initial application. It was noted that there was redundant vessel within the ring of the device due to incorporation of the diseased portion of vessel into the anastomosis. Initially, there was good flow, which was confirmed by Doppler ultrasonography; however, subsequently, the flow through the anastomosis slowed down, and, with further adjustment of the anastomotic device, the flow ceased. The temporary clips were then replaced and the vessel ends were divided more proximally and distally to remove the diseased portions, before being loaded onto a new anastomotic ring. The proximal and distal portions of the vessel were then reanastomosed with the aid of the microanastomotic device and excellent flow was again established (Fig. 4), which was confirmed by Doppler ultrasonography. The total time required for crossclamping during the second anastomotic procedure was also 10 minutes. A small amount of papaverine was placed along the vessels and the anastomosis was observed and rechecked several times by using Doppler ultrasonography. Blood flow was

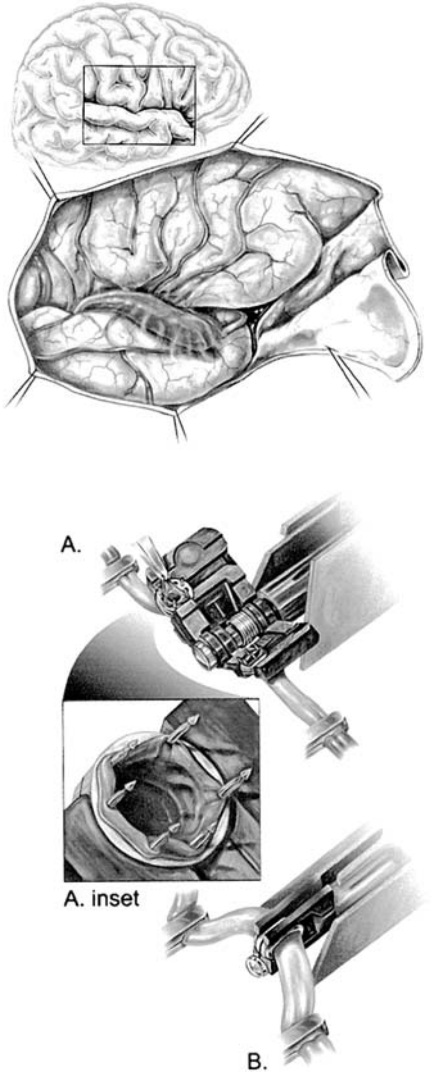

FIG. 2. Case 1. Artist's illustrations of the surgical procedure used in this case to create an IC–IC anastomosis of the cut ends of the parent vessel. *Upper:* Exposure of the aneurysm in the sylvian fissure (see *inset*). *Lower:* Following aneurysm excision, vessel loading into the microanastomotic device (A; close up shown in *inset*) and end-to-end anastomosis (B) are demonstrated.

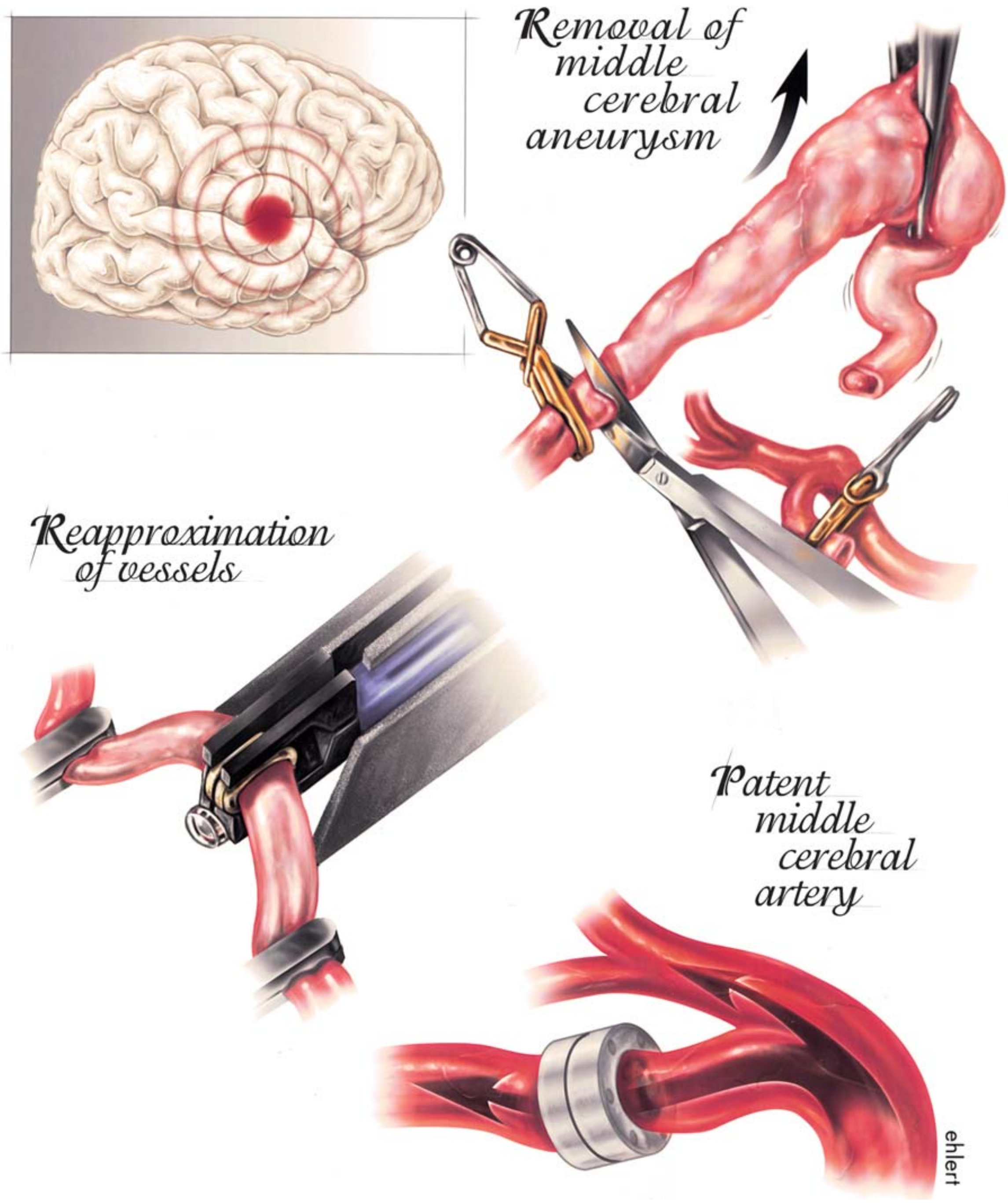

FIG. 3. Case 1. Artist's illustrations detailing the procedure used in this case. *Upper Left:* Site of the aneurysm. *Upper Right:* Removal of the MCA aneurysm. *Lower Left:* Reapproximation of the portions of the parent vessel. *Lower Right:* Reestablishment of flow in the patent MCA.

found to be present in the distal branch of the artery throughout the observation period.

Postoperative Course. Postoperative angiography demonstrated excellent flow through the anastomosis into the distal vasculature as well as complete elimination of the aneurysm (Fig. 5 *left*). Late repeated angiography performed 8 months after the procedure confirmed patency of the anastomosis, without significant narrowing (Fig. 5 *right*). The patient has returned to full activity without neurological deficits.

Case 2

History and Examination. After this 64-year-old man sustained a sudden collapse, he was found to be suffering from a large temporal lobe hemorrhage and a subarachnoid hemorrhage associated with an aneurysm located on

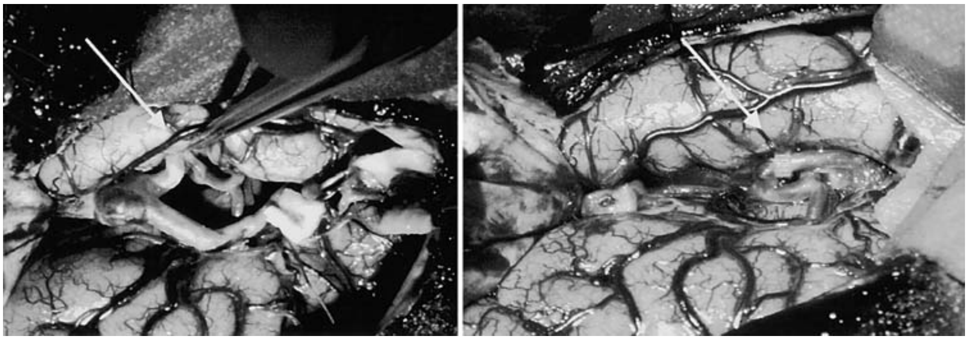

FIG. 4. Case 1. Intraoperative photographs of the sylvian vessels before *(left)* and after *(right)* excision of the aneurysm and reanastomosis of the vessels, which was achieved using the microanastomotic device. *Arrows* indicate the site of origin of the aneurysm on an M_2 branch of the MCA.

the distal MCA. There was no history of infection, and blood cultures and echocardiography subsequently failed to reveal any evidence of an infectious cause of his collapse.

A cerebral angiogram revealed a distally located ruptured aneurysm that originated from the largest angular branch of the MCA (Fig. 6). The area filled with contrast agent was small and measured approximately 6 to 7 mm. A contrast-enhanced CT scan, however, revealed a much larger aneurysm measuring approximately 1.5 cm in diameter.

Operation. The patient was taken to the operating room for urgent surgery because of the size and degree of midline shift associated with the hemorrhage. A right-sided craniotomy was performed and the temporal lobe hemorrhage was partially evacuated. The aneurysm was exposed and found to be located in the distal sylvian fissure and projecting into the superior temporal gyrus. The aneurysm was mostly firm and thrombosed, with a small amount of filling at the entry point of the proximal vessel. The aneurysm had incorporated the proximal and distal portions of the vessel and reconstruction with clips did not appear possible due to the firm nature and partial calcification of the lesion. We elected to excise the aneurysm and create a primary end-to-end anastomosis by using the microanastomotic device (Fig. 7). After the aneurysm had been measured, we selected the 2-mm ring. Temporary clips were placed on the proximal and distal portions of the vessel and these were then divided. The cut ends of the vessel were loaded on the opposing rings and the anastomotic procedure was performed. The temporary clips were released after 15 minutes and excellent flow was reestablished and confirmed by microvascular Doppler ultrasonography. The aneurysm was removed and the remainder of the hemorrhage was evacuated.

Postoperative Course. Postoperative CT scans demonstrated evacuation of the hematoma, and postoperative angiography revealed excellent flow through the anastomosis, with some mild narrowing at the site of anastomosis (Fig. 8 *left* and *upper right*). Follow-up angiography performed 7 months after the original surgery revealed resolution of the previous mild narrowing at the anastomotic site and normal flow through the vessel (Fig. 8 *lower right*). The patient required a replacement bone flap, a ventriculoperitoneal shunt, and subsequent drainage of a chronic subdural hematoma. He made a good recovery and has returned to full activity.

Discussion

The use of primary IC–IC anastomosis for the treatment of complex aneurysms offers the advantage of complete elimination of the lesion with restoration of blood flow to the parent vessel.[8] The cases presented in this article were

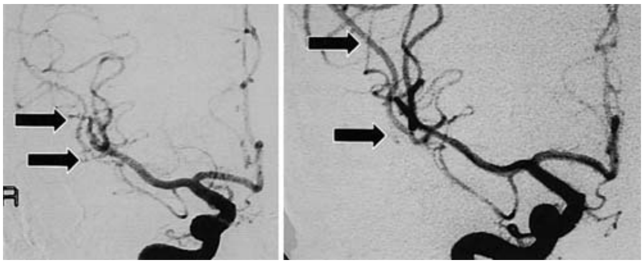

FIG. 5. Case 1. Angiograms depicting the reconstructed vessel 1 day after surgery *(left)* and 8 months after surgery *(right)*. The continued patency of the anastomosis is evident. *Arrows* indicate the vessel harboring the aneurysm; the *lower arrow* indicates the site of anastomosis.

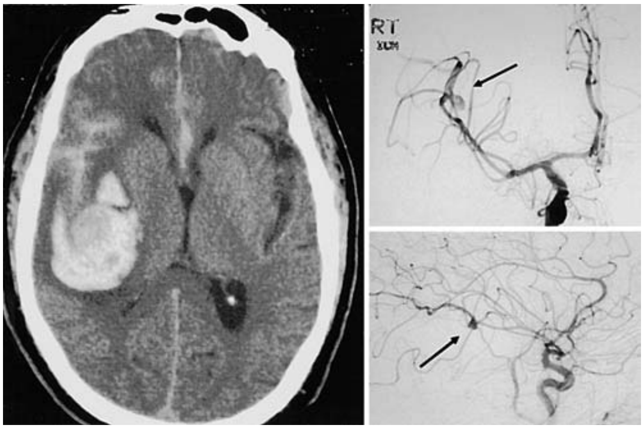

FIG. 6. Case 2. Computerized tomography scan *(left)* and anteroposterior *(upper right)* and lateral *(lower right)* angiograms obtained in a patient with a ruptured distal MCA aneurysm. There was only a small amount of filling of the aneurysm due to thrombosis of the majority of the lesion.

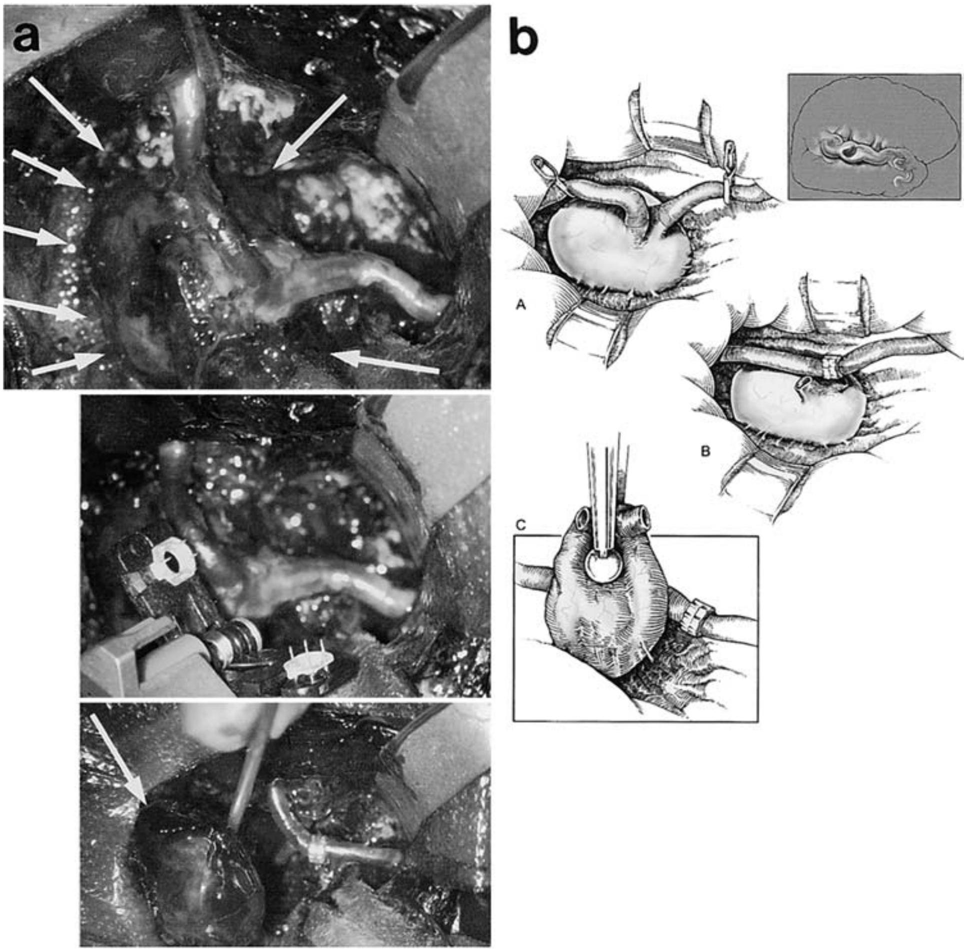

FIG. 7. Case 2. a: Intraoperative photographs showing exposure of the aneurysm with *arrows* indicating its outer diameter *(upper)*, introduction of the 2-mm-diameter rings on the microanastomotic device *(center)*, and removal of the aneurysm *(lower)*; *arrow* indicates the lesion. b: Drawings illustrating the location of the aneurysm in the distal sylvian fissure and hemorrhage in the right temporal lobe *(upper inset)*, exposure of the aneurysm and temporary clipping of the parent vessel (A), complete reanastomosis of the parent vessel with the aid of the microanastomotic device (B), and removal of the aneurysm (C).

ideal for this treatment because of several features of the aneurysms. The aneurysms were located distal to the main perforating arteries arising from the MCA trunk to supply the basal ganglia. There was also an absence of branching vessels on the parent vessels at the location of the aneurysms, allowing excision without interruption of flow through critical branches.

Another feature shared by these aneurysms, making them amenable to direct IC–IC anastomosis was the redundant nature of the distal M_2 branches, which provided the critical length needed for manipulating the vessels for anastomosis. The other treatment option, had the distal vessel been located further away from the aneurysm, would have included direct anastomosis of the distal branch to the STA or implantation of the distal vessel on other intracranial arteries.

The use of a microanastomotic device for anastomosis of small arteries and veins, accomplished using a coupling device without the need for sutures, was first described by Ostrup and Berggren.[12] Experimental studies in which the device has been used have confirmed excellent short- and long-term patency rates and high-quality strength of the anastomosis.[2,14,15] The time required to perform the anastomotic procedure is shorter than that needed using the classic suture method. This system has been used in plastic and reconstructive surgery to create very high quality anastomoses with lumen-to-lumen contact of vessels and high patency rates.[11]

We previously described the microanastomotic device and its use in the intracranial circulation to perform EC–IC bypass procedures; in those circumstances we observed excellent short- and long-term patency rates.[9] A distinct advantage of this method, compared with microsurgical techniques involving sutures, is the shorter time required to perform the anastomotic procedure on cerebral vessels, which may reduce the risk of ischemic neuronal damage. An additional advantage lies in the fact that the rings are compatible with magnetic resonance imaging.[4]

There are several cautions that should be noted when using the device. It is important to select the ring that most closely matches the size of the vessel. A ring that is too large may result in tearing of or damage to vessel ends

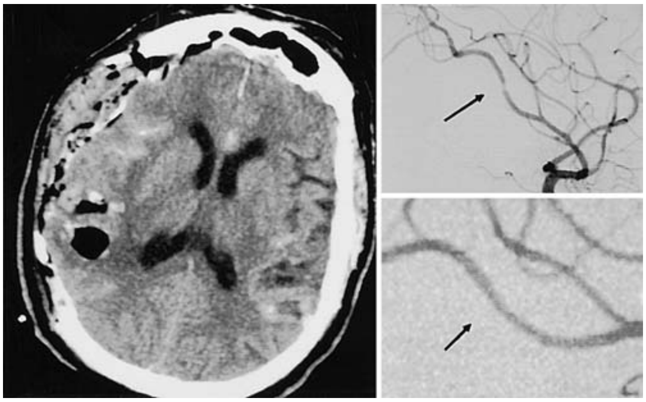

FIG. 8. Case 2. Postoperative CT scan *(left)* and angiograms *(right)* illustrating absence of the aneurysm and patency of the parent vessel. There is mild narrowing of the vessel at the site of anastomosis on the initial postoperative angiogram *(upper right, arrow)*. A late follow-up angiogram obtained 7 months after surgery reveals normal filling of the angular MCA branch that originally harbored the aneurysm and resolution of the previous mild narrowing of the vessel *(lower right, arrow)*.

when they are loaded for use. A ring that is too small can result in redundancy of the vessel within the ring and this can obstruct flow. The size of the ring that is selected is based on the measurement of the vessel obtained using a specially designed gauge. The rings provided are sized in 0.5-mm increments from 1 to 3 mm. Smaller increments may be advantageous for use in the cerebral circulation. It is also important when loading the cut ends of the vessel into the rings to use Pierce ring-end forceps. These forceps have a small groove located just proximal to the tip that allows the cut end of the vessel to be grasped without damaging it.

It is important to try to excise the lesion back to normal portions of the vessel when performing the anastomotic procedure. During the initial anastomosis described in Case 1, we included partially diseased portions of vessel, which should be avoided when using the microanastomotic device. It is important to note that the ring only allows a certain thickness of vessel; if this thickness is exceeded, the result can be an accumulation of redundant portions of vessel within the ring, subsequently compromising the lumen, which occurred during the first attempt at anastomosis in Case 1.

The current design of the device makes it suitable for working on the surface of the brain and in the sylvian fissure; however, it is difficult to use in deeper recesses of the brain because of the size and configuration of the applicator.

Conclusions

The microanastomotic device may be useful in treating a variety of intracranial lesions such as large, giant, or fusiform aneurysms, which require excision and primary reanastomosis of intracranial vessels. The ease of use, quality of the anastomosis, and short crossclamp time may offer advantages over microsuture techniques for primary end-to-end anastomosis of intracranial vessels.

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Disclaimer

None of the authors has any financial interest in the device described in this article.

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Address reprint requests to: David W. Newell, M.D., Department of Neurological Surgery, Harborview Medical Center, 325 Ninth Avenue, Seattle, Washington 98104. email: DWN@u.washington.edu.