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Original Article

Superficial temporal artery-middle cerebral artery bypass surgery for recurrent middle cerebral artery aneurysms after coil embolization: a case report and literature review

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Abstract: In this article, we describe our institutional experience with the treatment for recurrent middle cerebral artery (M1) aneurysms (MCA-AN) after coil embolization using superficial temporal artery-middle cerebral artery (STA-MCA) bypass surgery. A 24-year-old male patient was diagnosed with MCA-AN by digital subtraction angiography (DSA) in Beijing Tian Tan Hospital. He underwent stent-assisted coil embolization of the aneurysms in Cedars-Sinai Medical Center, U.S., but the MCA-AN recurred at 6 months after the surgery. He further received endovascular coiling treatment in Cedars-Sinai Medical Center, but the surgeons failed to successfully complete the operation. Subsequently, the patient was transferred to Beijing Xuanwu Hospital and underwent STA-MCA bypass surgery in May 2017. The patient was followed up for over 1 year and no recurrent MCA-AN was observed. The diagnosis and therapeutic procedures of this case suggest that STA-MCA bypass surgery is probably a good option for patients presenting with recurrent MCA-AN following coiling embolization.

Keywords: Superficial temporal artery, middle cerebral artery (MCA) aneurysms, coil embolization

Introduction

Middle cerebral artery (MCA) aneurysms are characterized by a fusiform morphology, an intraluminal thrombus, atherosclerotic tissues affecting the neck, major arterial branches incorporated into the aneurysm base, or a broad neck [1], which creates a significant challenge for conventional endovascular coiling embolization.

The MCA is the largest cerebral artery that supplies the majority of brain cortex, the basal ganglia, and the anterior and posterior internal capsules. Direct vessel trapping or endovascular occlusion of the MCA to obliterate the aneurysms imposes a high risk of ischemic stroke, leading to diverse neurological injuries [2].

Extracranial-intracranial bypass surgery is a revascularization technique carried out in cerebral arteries through the EC arteries and was primarily invented to prevent the incidence of recurrent cerebral ischemic strokes. Superficial temporal artery (STA)-MCA bypass surgery is one of the most frequently adopted procedures. Previous research has demonstrated that STA-MCA bypass can reduce the risk of MCA ischemic stroke through blood flow replacement and augmentation [3-5]. If conventional endovascular coiling for MCA and internal carotid artery (ICA) aneurysms is not effective, bypass surgery may be considered for treating the aneurysm.

It is rarely reported that superficial temporal artery-middle cerebral artery bypass surgery was performed for recurrent middle cerebral artery aneurysms after coil embolization. Neurosurgeons have limited common experience with the diagnosis and treatment of this kind of aneurysm. In this report, we present the diag-

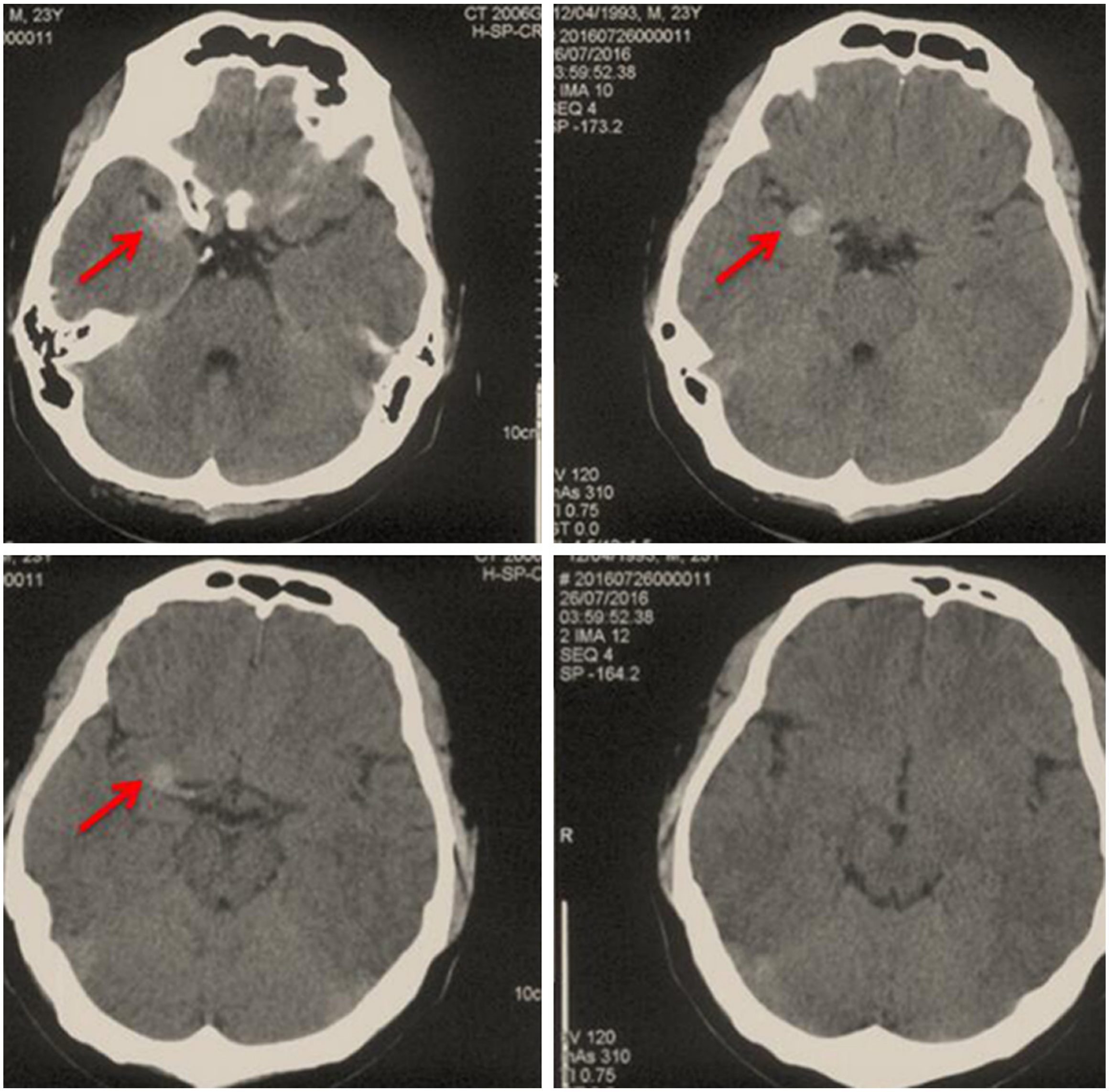

Figure 1. Preoperative CT scan of the head. The hyperdense round-shaped lesion in the lateral fissure was not complicated with a subarachnoid hemorrhage. The red arrow indicates a round lesion in the right sylvian fissure.

nostic and treatment experience at different institutions for a patient with recurrent MCA-AN following endovascular coiling treatment, after which the patient subsequently underwent STA-MCA bypass surgery. The surgical efficacy and safety are reported here.

Case report

Medical history

The male patient, 24 years old, presented with a sudden weakness in speaking and a lack strength in his left limbs on July 26, 2016. He received a CT scan of the head, revealing a hyperdense, round-shaped lesion in the sylvian fissure which was not complicated with a subarachnoid hemorrhage (SAH), as illustrated in **Figure 1**. Two days later, he was transferred to Beijing Tian Tan hospital and underwent a digital subtraction angiography (DSA) showing the MCA-AN located at the right M1 segment (**Figure 2**). Given the risk of craniotomy clipping surgery due to abundant vessels, his family rejected the doctors' offer to perform a craniotomy, and then the patient was transferred to Cedars-Sinai Medical Center, U.S. for a stent-assisted coil embolization of the aneurysms in September 2016 (**Figure 3**). However, 6 months later, DSA showed the M1 segment MCA-AN

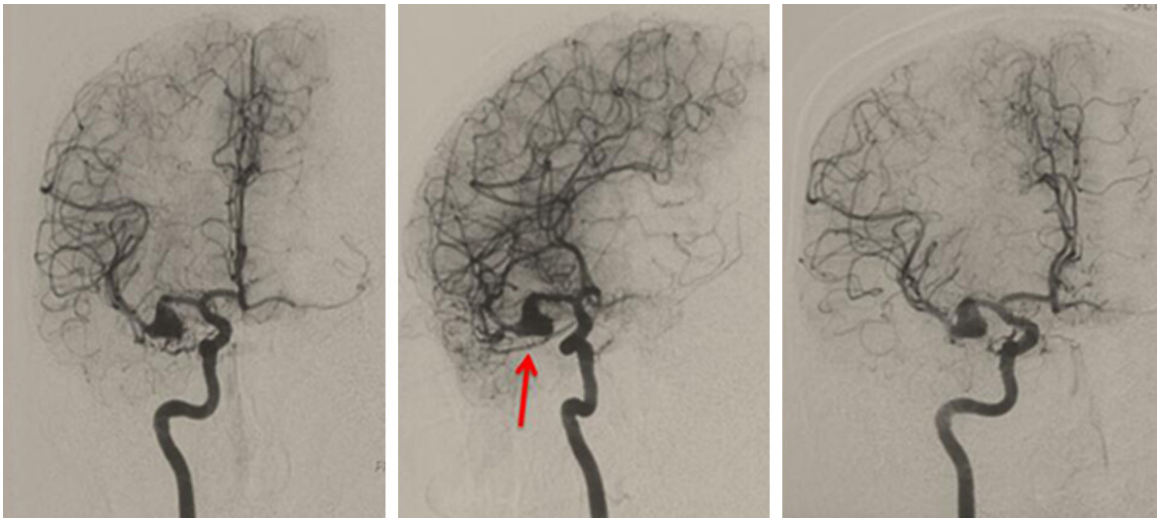

Figure 2. Preoperative DSA of the head. The red arrow indicates a dissecting AN located in the right M1 segment of the MCA.

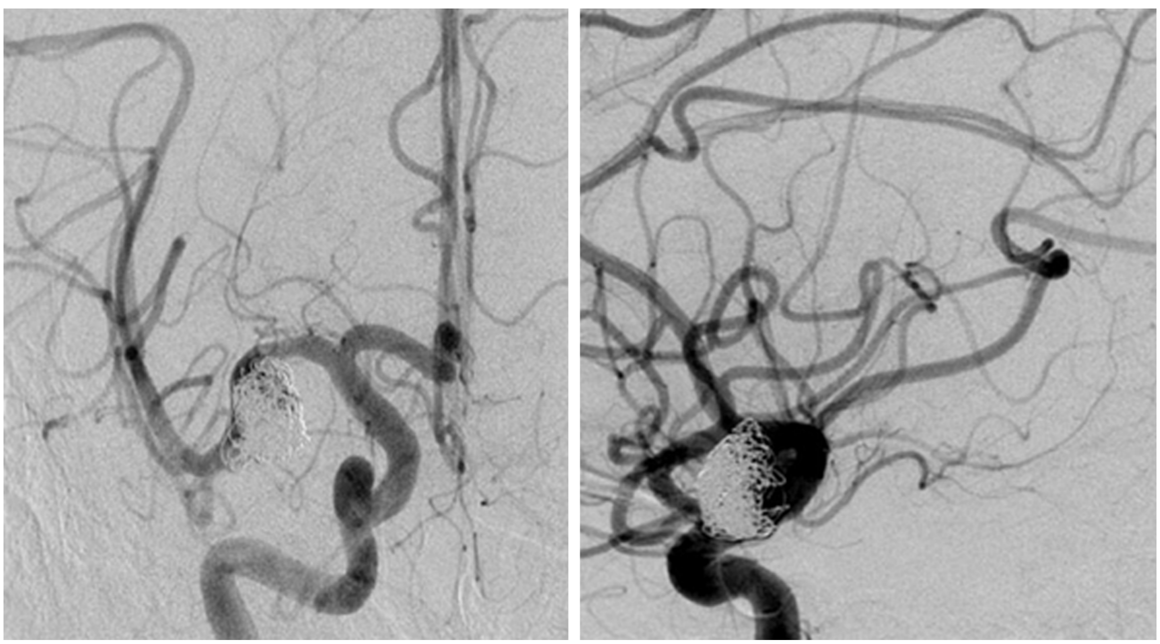

Figure 3. Postoperative DSA of the head illustrating that the embolization was satisfied and the parent artery was unobstructed.

had recurred (**Figure 4**). On April 18, 2017, the patient was returned to Cedars-Sinai Medical Center, U.S. for endovascular coiling treatment. This time the neurosurgeons were unable to pass through the stent to place a pipeline device and did not coil the AN because of the high risk of obliterating any flow to the distal MCA territory. Due to this complex situation, the neurosurgeon recommended that the patient undergo direct STA-MCA bypass surgery. T1- and T2-MRI were performed before the 2nd surgery on May 4, 2017 (**Figure 5A**, **5B**). On May 8, 2017, he successfully underwent STA-MCA bypass surgery in Beijing Xuanwu Hospital (**Figure 5C**). Following the bypass surgery, the proximal M1 segment was occluded to obliterate the AN. Postoperative DSA revealed no signs of the MCA-AN in the M1 segment (**Figure 6**).

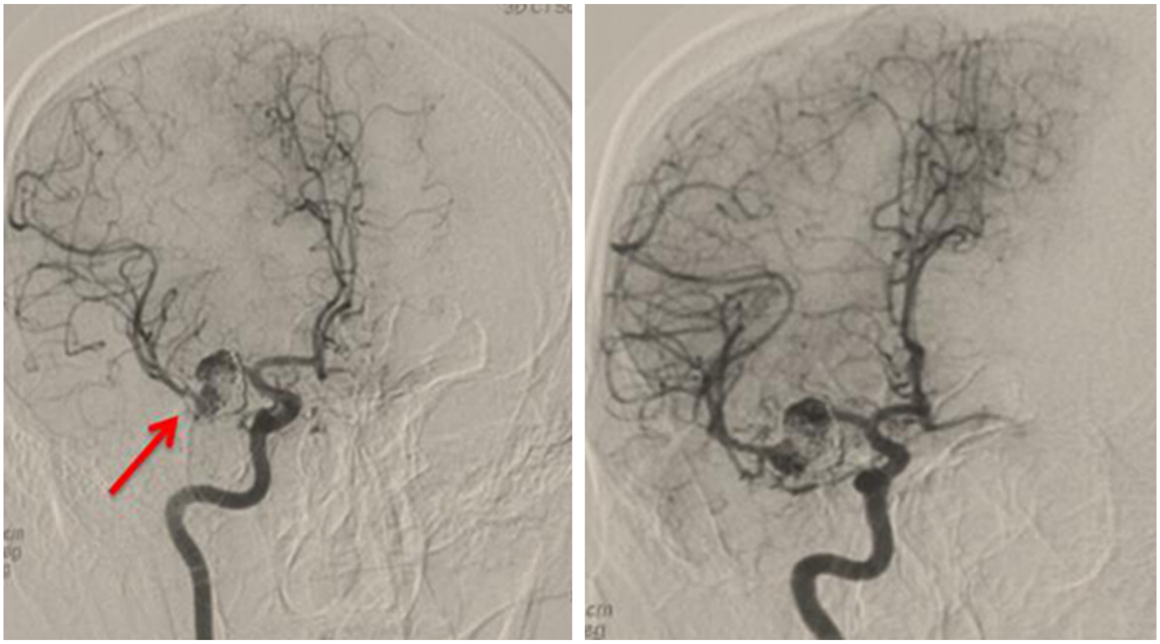

Figure 4. DSA of the head during postoperative follow-up. The red arrow denotes the MCA-AN in the right M1 segment was recurrent.

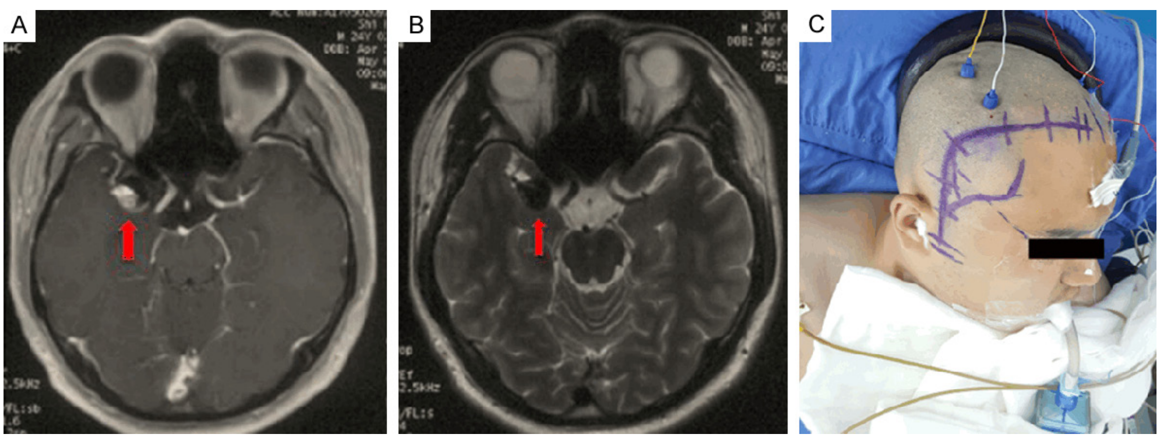

Figure 5. Preoperative T1-MRI (A) showing partial thrombus in the right M1 segment MCA, T2-MRI (B) detecting a round low signal in the right temporal lobe (red arrow) and preoperative preparations (C).

STA-MCA bypass surgery

A direct end-to-side anastomosis of the STA branch and the cortical branch of the MCA was successfully performed. The donor and recipient vessels, which were approximately 1 mm in size, were chosen for the bypass surgery. The STA-MCA bypass surgery was performed through a frontotemporal scalp incision which preserved the STA branches. The donor branch of the STA was dissected from the inner surface of the scalp flap. A small craniotomy centered approximately 6 cm from the external auditory canal exposed the distal MCA branches as they exited from the sylvian fissure. After choosing a suitable recipient artery, the overlying arachnoid and pia mater was cut open and the vessels were prepared for subsequent bypass surgery. Under microscopic observation, the end-to-side anastomosis was successfully accomplished using the interrupted sutures with 10-0 Prolene. The craniotomy bone flap was placed back after removing a small edge of the bone to enable the passage of the STA branches. The

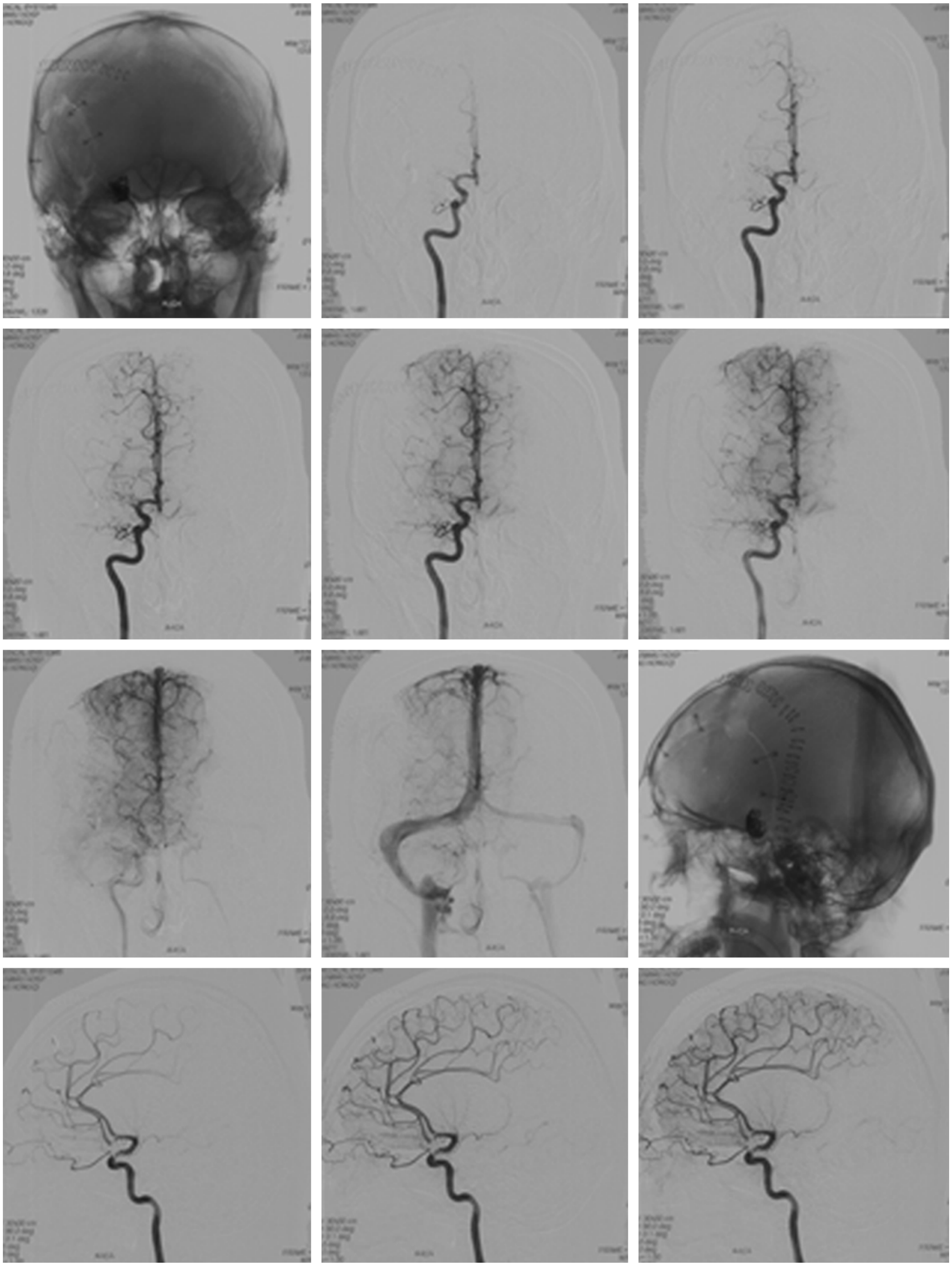

Figure 6. Postoperative DSA of the head revealed no signs of the MCA-AN in the M1 segment.

scalp was then closed in layers with the Vicryl and prolene sutures. The degree of anastomosis patency was evaluated by cranial Doppler ultrasound. Indocyanine green (ICG) was used

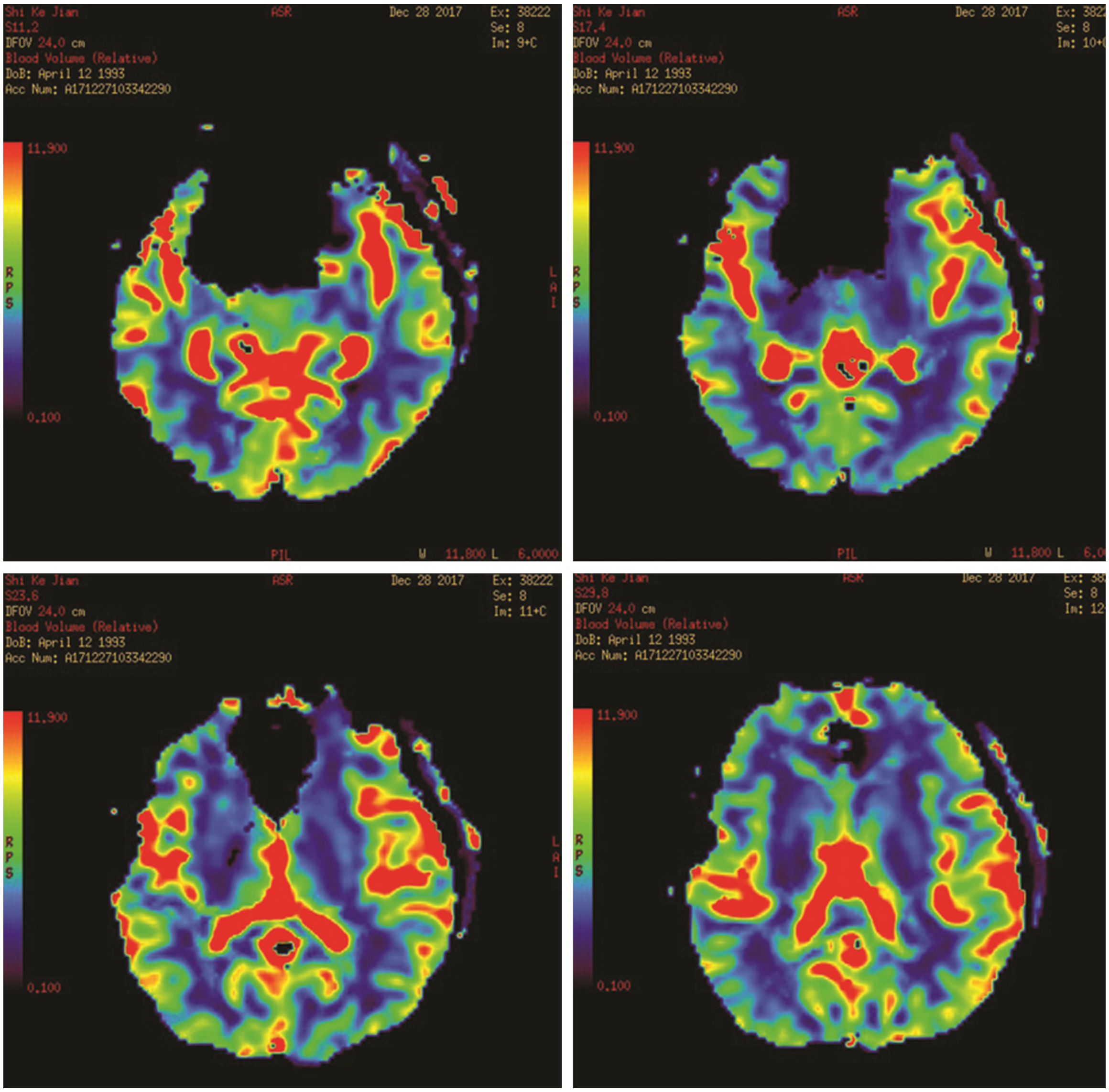

Figure 7. Postoperative perfusion-magnetic resonance imaging. No abnormalities or recurrent MCA-AN were detected.

to observe the blood flow within the brain arteries.

Postoperative follow-up

During postoperative follow-up, the patient's consciousness was clear. He suffered no neurological defects. In addition, the symptoms of his right limb weakness were significantly alleviated. On December 28, 2017, the patient received perfusion-magnetic resonance imaging (MRI). No abnormalities or recurrent MCA-AN were detected (**Figure 7**). At 6 months and 1 year after the surgery, the patient underwent a transcranial color-coded duplex sonography (TCCD) demonstrating the signs of excellent patency from the STA branches towards the MCA branches (**Figure 8**).

Discussion

Previous studies have demonstrated that STA-MCA bypass surgery is an efficacious treatment for cerebral aneurysms and tumors located at the base of the skull which are involved in major vascular invasiveness [6-8]. STA-MCA bypass surgery is commonly divided into the following four patterns: *in situ* bypass in a side-to-side

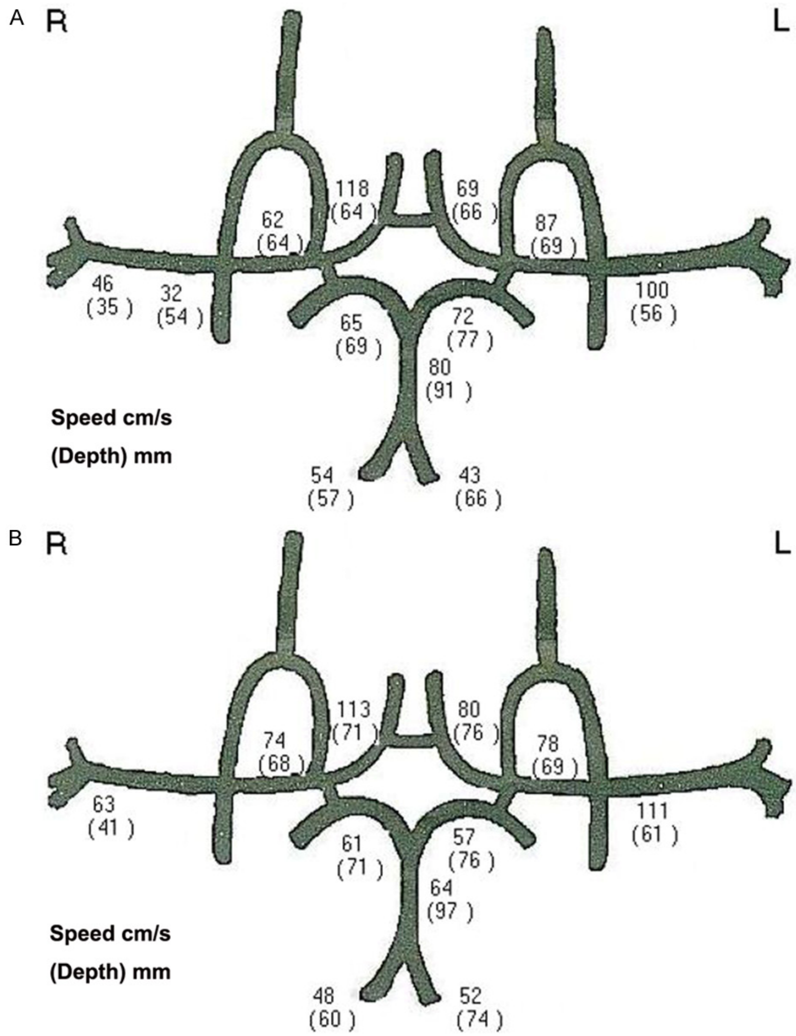

Figure 8. Transcranial color-coded duplex sonography (TCCD) demonstrating excellent patency from the STA branches towards the MCA branches at postoperative 6 months (A) and 12 months (B).

(STS) fashion, re-implantation bypass in an end-to-side fashion, re-anastomosis bypass in an end-to-end fashion, and inter-positional bypass using a graft vessel [9]. Of these four patterns, the *in situ* bypass technique connects two similar arteries and creates an artificial conduit for shared blood flow. Meanwhile, STA-MCA bypass surgery is a low-flow bypass technique, which can provide sufficient perfusion and fewer surgical complications [10]. Therefore, low-flow bypass surgery yields a lower incidence of perioperative ischemic stroke, but it leads to a higher patency rate at certain anatomical segments compared to a high-flow bypass procedure [11, 12]. STA-MCA bypass provides additional blood flow to gain more ischemic time for aneurysm clipping and to prevent ischemic stroke after the sacrifice of parent arteries for complex MCA aneurysms.

In this case, the craniotomy option was rejected by the parents of the 24-year-old patient considering his abundant vessels, and then the patient was transferred to Cedars-Sinai Medical Center, U.S. for a stent-assisted coil embolization of the aneurysms. Unfortunately, DSA showed the M1 segment MCA-AN was recurrent 6 months later. Endovascular coiling provides less relief from a mass effect. This suggests that the microsurgical clipping of complex aneurysms is still superior to endovascular embolization, and it should remain the first treatment of choice [13-15]. Subsequently, the patient was returned to Cedars-Sinai Medical Center, U.S. for endovascular coiling therapy. This time the neurosurgeons were unable to pass through the stent to place a pipeline device and failed to coil the AN due to the high risk of obliterating any flow to the distal MCA territory. Due to this complex situation, the neurosurgeon then recommended the patient undergo direct STA-MCA bypass surgery. The diagnostic and therapeutic experience in this case hints that the selection of the type of bypass surgery should be individualized based upon the specific conditions of each patient.

Conclusion

The findings in this case highlight that STA-MCA bypass surgery is still essential for complex MCA aneurysms even if significant advancements have been achieved in terms of surgical clipping and endovascular treatment, which can achieve significant obliteration and favorable clinical outcomes for a majority of MCA aneurysms in clinical practice. At postoperative 1 year, TCCD demonstrates the excellent patency from the STA branches towards the MCA branches, and the MCA-AN does not recur.

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Disclosure of conflict of interest

None.

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