Distal Middle Cerebral Artery Aneurysms

Endovascular Treatment Results with Literature Review

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Summary

Intracranial aneurysms of the distal intracranial arteries are uncommon lesions which are difficult to treat with surgical techniques. Distal middle cerebral artery (MCA) aneurysms constitute approximately 5% of all MCA aneurysms. We report the results of our coil embolization for the treatment of distal MCA aneurysms.

Eleven patients (four men and seven women, average age 37 years) with distally located MCA aneurysms were treated. Four of the aneurysms were fusiform in shape and the remainder were saccular.

Seven of the aneurysms were in the dominant hemisphere.

Four of the seven patients who had saccular aneurysms were treated with selective aneurysm embolization. The remaining seven patients were treated with aneurysmal sac and parent artery coiling. All patients had good retrograde flow into the peripheral branches of the occluded artery. All the procedures were completed successfully without any additional neurological deficits.

Coil embolization is a safe and effective technique for the treatment of distal MCA aneurysms.

If the parent artery cannot be preserved, pial collaterals can supply adequate blood to prevent neurological deficits.

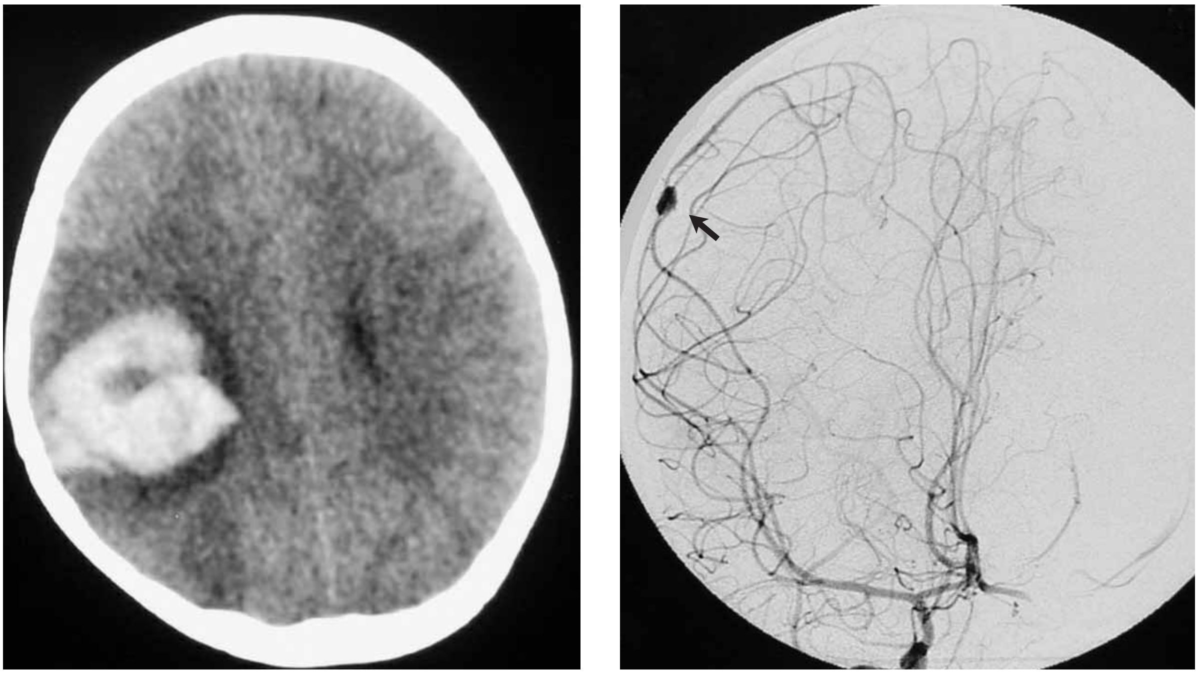
Introduction

Intracranial aneurysms occurring along the distal branches of the cerebral arteries are uncommon compared to saccular aneurysms developing along the proximal trunks of the circle of Willis [1]. Aneurysms arising from major arteries near the circle of Willis are easy to localize and treat surgically whereas distal aneurysms of peripheral branches are often difficult to localize at the time of the operation [2]. Improvements in catheter technology have made distal aneurysms more accessible for endovascular coil packing with detachable coils.

There are quite a number of papers in the literature about either endovascular or surgical treatment of aneurysms of the distal intracranial arteries. Most of these reports concern distal aneurysms of the posterior circulation (posterior cerebral artery, posterior inferior cerebellar artery, superior cerebellar artery), distal anterior cerebral artery, and giant serpentine aneurysms of the middle cerebral artery (MCA) territory [3-10]. We present our experience with the endovascular treatment of patients with distal MCA aneurysms.

Material and Methods

In a retrospective analysis of 512 aneurysms treated with an endovascular approach in our department between 1993 to 2001, there were



11 patients with distal MCA aneurysms treated with coil embolization. Aneurysms located beyond the major bifurcation of the MCA are referred to as distal MCA aneurysms. The patients were three to 62-years-old (average age 37 years) at the time of treatment. Four patients were male and seven were female.

The diameter of the aneurysms ranged from 3 mm to 35 mm with a mean diameter of 9 mm. Four of the aneurysms were fusiform in shape and the remainder (7/11) were saccular. Two of the saccular aneurysms had wide necks. Three aneurysms had partial thrombosis. Five aneurysms were located on the right and six on the left MCA branches. Seven of the aneurysms were in the dominant hemisphere.

One of the aneurysms was a ruptured distal MCA pseudo-aneurysm that resulted from a parietal bone fracture secondary to head trauma. There was a left parietal haematoma which did not require surgical evacuation (figure 1). Another patient who presented with a right parietal haematoma had a previous diagnosis of infective endocarditis. The haematoma was evacuated in the emergency room and no evidence of an aneurysm was noted at the time of surgery.

The patient recovered fully after the operation and cerebral angiography revealed a distal mycotic aneurysm of the right MCA. There were no predisposing factors for aneurysm formation in the rest of the cases.

Four patients had subarachnoid haemorrage (SAH) of Hunt and Hess Grade I. Two patients had intraparenchymal haematoma and they were also Hunt and Hess Grade 1 before the endovascular treatment. One patient had previous of SAH, but had no available imaging related to this event. Three patients had aneurysms detected during the investigation for their headaches. One patient had transient hemiparesis and epileptic attacks. Clinical characteristics of patients are summarized in table 1.

All endovascular treatments except one were performed under general anesthesia and full heparinization. The heparinization protocol was a bolus of 5000 IU at the beginning of the procedure, followed by an injection of 1000 IU of heparin per hour with ACT control.

Aneurysms were occluded with Guglielmi detachable coils (GDCs; Target Therapeutics, Fremont, CA) or Micrus coils (Micrus Co. Irvine CA). Fusiform aneurysms were treated with end-to-end packing of the aneurysm along with the parent artery occlusion (figure 2). In all patients with saccular aneurysms, except the ones with traumatic and mycotic origin, the first goal was to selectively embolize the aneurysm itself with preservation of the parent artery. In cases in which the parent artery could

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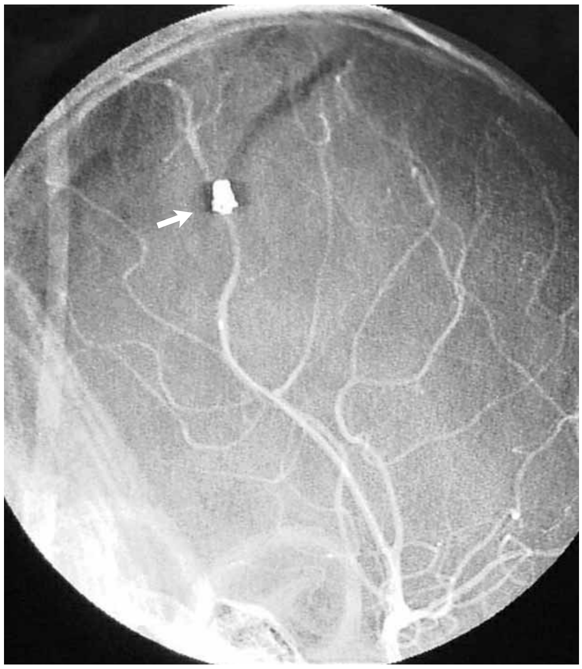

not be spared, the treatment was accomplished with intra-aneurysmal coil packing with extension into the parent artery resulting in the occlusion of both the aneurysmal sac and the parent artery. We did not perform amytal test in any of our patients.

Angiography was performed in all cases immediately after the procedure to show the complete exclusion of the aneurysms from the circulation. We also evaluated the distal reconstruction of the occluded artery with leptomeningeal collaterals in which the parent artery was closed (figure 3).

All patients were put on heparinization for three days after the procedure. The heparin infusion dose was 750-1000 IU/hr based on their weights. In the patients in whom the parent artery was occluded, a large central venous catheter was inserted for volume loading. The systolic blood pressure was kept above 150 mmHg for 24 hours to increase the flow through the pial collaterals to the territory of the occluded artery.

Pre- and postoperative neurological functions were evaluated using the Glasgow Outcome Scale (GOS). All patients were discharged after the three-day heparin infusion without any complaints. All patients had clinical and radiological follow-up with angiography and magnetic resonance (MR) imaging at six month intervals.

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Figure 1 Three-year-old girl with a parietal bone fracture secondary to a head trauma. A) Non-enhanced axial CT scan. Large right parietal haematoma. B,C) Anteroposterior and lateral right internal carotid arteriogram. Saccular aneurysm of distal posterior parietal artery branch of MCA adjacent to the bone (black arrows). D,E) Lateral non-subtracted and subtracted post-embolization arteriograms. Total occlusion of the aneurysm sac with preservation of the parent artery (black arrowheads). Note the relationship between the aneurysm sac and the fracture line (white arrows)

Results

Four of the seven patients who had saccular aneurysms, including the traumatic case, were treated with selective aneurysm embolization. The remaining seven patients including the four fusiform and the three saccular aneurysms -two of them with wide necks- were treated with aneurysmal sac and parent artery coiling and they had good retrograde flow into the peripheral branches of the occluded artery through pial anastomoses. The endovascular procedure was successful In all patients and no residual filling of the aneurysm was seen in any of the patients at the immediate control angiography. One of the patients in whom the aneurysm was selectively embolized had mild transient sensorial dysphasia that resolved within 12 hours after the operation. None of the other patients had any neurological deficit or technical complication related to the procedure.

Ten of the eleven patients had follow-up angiography with a 17 month average (range, six months to three years). Contact with one patient with a saccular aneurysm was lost during follow-up. In one of the patients, there was recurrent filling of the aneurysm neck on angiographic control in the sixth month (figure 4). Since the regrowth was too small and there was stagnation of contrast material at that site, no further intervention was deemed necessary and the patient was to be followed with angiographic controls. In the remaining patients, control angiograms did not show any recurrent filling of the aneurysms.

Immediate and follow-up MR imaging was obtained in the patients in whom the parent artery was occluded. In four of these patients, no abnormality appeared in the post-operative and follow-up MR examinations. In three patients, on the other hand, some tiny non-specific hyperintense foci ipsilateral to the treated aneurysms were observed on T2-weighted MR images.

Discussion

Aneurysms located in the distal intracranial vessels are rare. They constitute approximately 7% to 9% of anterior cerebral artery aneurysms, 2% to 7% of MCA and 5% of posterior cerebral artery aneurysms [11]. According to the large series of Rinne et Al, 4% of all MCA aneurysms were distal [12]. Heros et Al reported that aneurysms beyond the major bifurcation of the MCA represented 5% of all MCA aneurysms [13].

The most common etiology in distal intracranial aneurysms is infection with mycotic emboli resulting in secondary aneurysm formation [14-16]. They may also be related to trauma, vasculitis, tumor emboli or directly to an intracranial neoplasm [17]. In our series, there were mycotic and traumatic aneurysms, one of each.

Distal aneurysms present some difficulties in surgical treatment. It is often difficult and time-consuming to localize the aneurysm by following major arterial trunks distally [2]. In their series of giant distal aneurysms, Drake et Al reported that most of the distal aneurysms could not be directly clipped and were treated with proximal occlusion [18]. Therefore, for that group of patients with distal lesions, it may be reasonable to refer the patients directly to endovascular procedures.

Parent vessel occlusion has been widely reported in the literature for treatment of aneurysms of the internal carotid artery and distal vertebral artery [19-21]. Since intracranial circulation has adequate pathways through the circle of Willis, the technique is an acceptable way of treatment in such aneurysms. On the other hand, inadvertent occlusion of the MCA in most patients leads to infarction and serious neurological disabilities with possible fatalities.

There have been several reports of M2 branch occlusions with minimal or no deficits [7,9]. In giant fusiform or serpentine aneurysms of the MCA territory, the most effective way to treat the aneurysm is the direct and permanent occlusion of the parent artery [6-9,22], since it may be the only way of eliminating such aneurysms in selected cases. Ross et Al reported their experience in the endovascular treatment of distally located giant aneurysms [9]. They treated ten patients with selective aneurysm coiling, and nine with parent artery occlusion. They stated that the major problem with giant aneurysms was coil compaction in cases with selective aneurysm embolization. Therefore, for giant aneurysms, parent vessel occlusion with or without aneurysm embolization was the effective and may be the only treatment modality. Hodes described endovascular treatment of 16 patients with giant intracranial aneurysms eight

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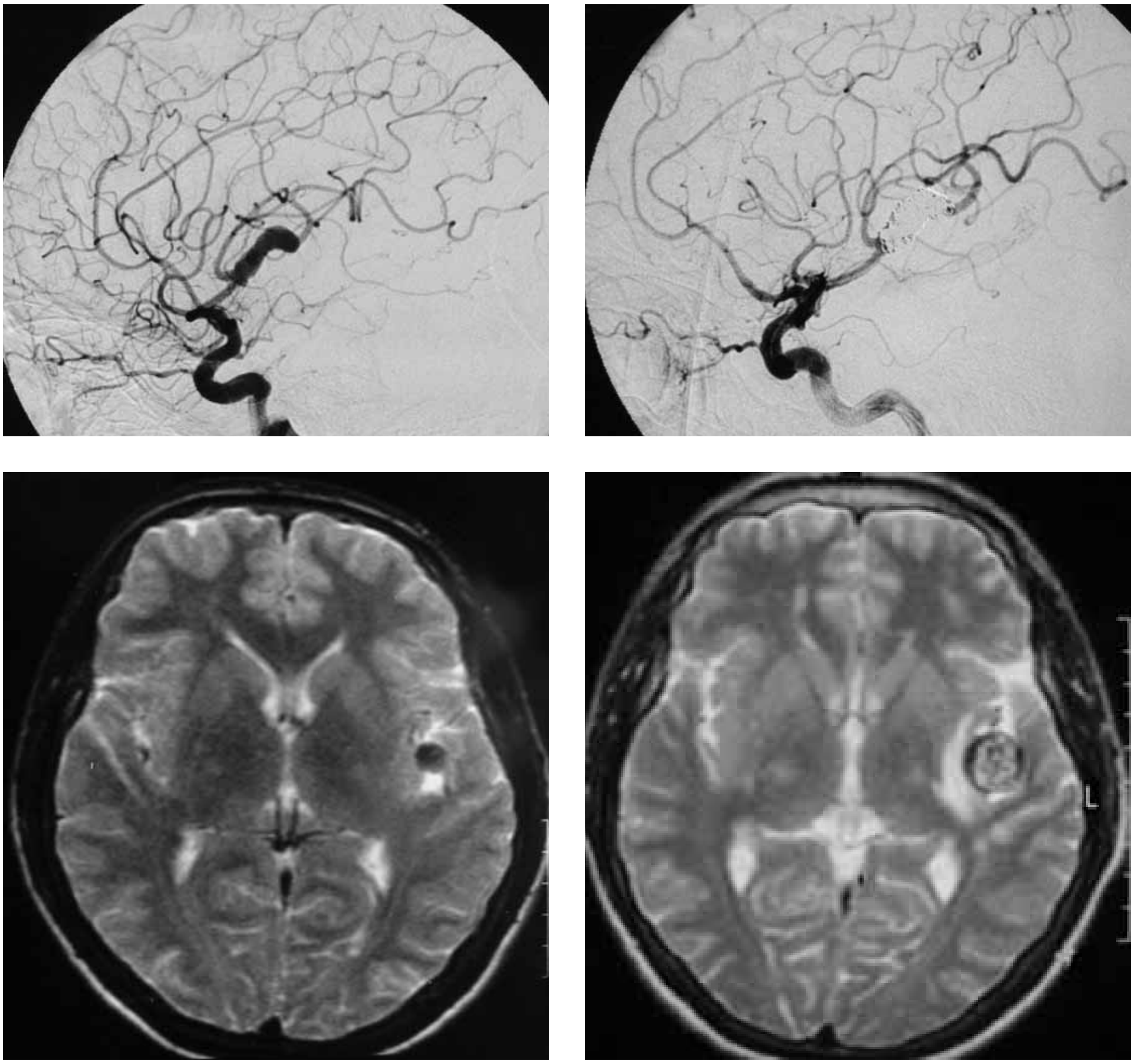

Figure 2 37-year-old man with a history of subarachnoid haemorrhage. A) Lateral left internal carotid arteriogram. Fusiform dilatation of angular artery branch of MCA is seen. B) Lateral postembolization view. Complete closure of the aneurysmatic segment with end-to-end packing with coils. Note the antegrade filling of the artery distal to the aneurysm, that is expected to be thrombozed slowly. C,D) Pre- and postembolization T2-weighted axial MR images. The tiny hiperintensities indicating ischemic changes.

of which were distally located. Four of them were in the MCA territory [4]. He reported minimal or no deficits after parent vessel occlusion.

Eckard et Al reported their experience with occlusion of the parent artery for the treatment of peripheral intracranial aneurysms [4]. Seven of the nine patients had aneurysms of the posterior circulation, one in the MCA, and one in the anterior cerebral artery. The procedures were uneventful except for mild neurological disabilities which developed in three patients.

Chun et Al reported a meta-analysis of the data of infectious aneurysms [16]. Among 23 mycotic aneurysms, 17 aneurysms were treated with endovascular procedures, eight of which were located in the distal MCA territory. Six of these eight patients were treated with parent artery occlusion and two underwent selective coiling of the aneurysmal sac. All the patients treated with parent artery occlusion had a good outcome without any complication and one patient treated with selective coiling developed hemiparesis. Although there is an objection to the use of coils in the endovascular treatment of mycotic as well as traumatic aneurysms because of their fragile walls, with the newly developed soft coils, it is now possible to treat these pathologies with coils. Chun et Al stated that they performed coil occlusion for mycotic aneurysms exhibiting saccular morphology because this preserved the parent artery and this treatment could be accomplished with minimal aneurysmal manipulation and risk of rerupture [16].

Cognard et Al reported three cases of distal cerebellar artery aneurysms (two at PICA, one at superior cerebellar artery) which were treated with intra-aneurysmal glue injection [1]. In two cases, the aneurysms were totally occluded with preservation of the parent artery, and in one case both aneurysm and the parent artery were occluded. It is stated that distally located aneurysms that cannot be reached with microcatheters can actually be reached with flow guided catheters, and glue injection with the control of blood flow within the aneurysm is a safe and efficient alternative to endovascular treatment with GDCs. The major problem with this technique is inadvertent distal migration of glue to the normal arteries and reflux, so the operator should be highly skilled in glue injection. On the other hand, it is possible to reach even the most distally located aneurysms with the developments in the microcatheter and microwire technologies which make the endovascular GDC technique more feasible.

The present series comprises only distally located MCA aneurysms, consisting of seven saccular, and four fusiform types. There were no giant or serpentine aneurysms. When a fusiform aneurysm is present, the aneurysmal vascular segment was packed starting from the distal end to the proximal parent artery. When possible, selective occlusion of the saccular aneurysm is the method of choice. But due to the small caliber of the parent artery accompanying these distal aneurysms, even minimal expansion of the coil pack can result in the occlu-

Table 1 **Summary of the patients' clinical data**

Patient No	Age & Sex	Location	Presentation	Aneurysm Type	Treatment	Complications	*GOS Score
1	62 F	R MCA, angular a.	Headache	Saccular	AO, PAO	None	1
2	26 F	R MCA, posterior parietal a.	Headache	Fusiform	AO, PAO	None	1
3	10 M	R MCA, distal prerolandic a.	Intraparenchymal haematoma, SAH	Saccular	AO, PAO	None	1
4	3 F	R MCA, posterior parietal a.	Intraparenchymal haematoma Hemiparesis	Saccular	SAO	None	2
5	51 F	L MCA, angular a.	Incidental	Saccular	AO, PAO	None	1
6	24 M	L MCA, distal inferior trunk	Seizures	Saccular	SAO	None	1
7	59 F	L MCA, inferior trunk	SAH	Saccular	SAO	None	1
8	48 F	L MCA, angular a.	SAH	Saccular	SAO	Mild transient sensorial dysphasia	1
9	37 M	L MCA, angular a.	Previous history of SAH	Fusiform	AO, PAO	None	1
10	59 M	L MCA distal inf. trunk	Headache	Fusiform	AO, PAO	None	1
11	36 F	L MCA; angular a	Headache	Fusiform	AO, PAO	None	1

*Abbreviations: MCA: middle cerebral artery, a: artery, SAH: subarachnoid hemorrhage, AO: aneurysm occlusion, SAO: selective aneurysm occlusion, PAO: parent artery occlusion, *GOS: Glasgow outcome scale after the procedure.*

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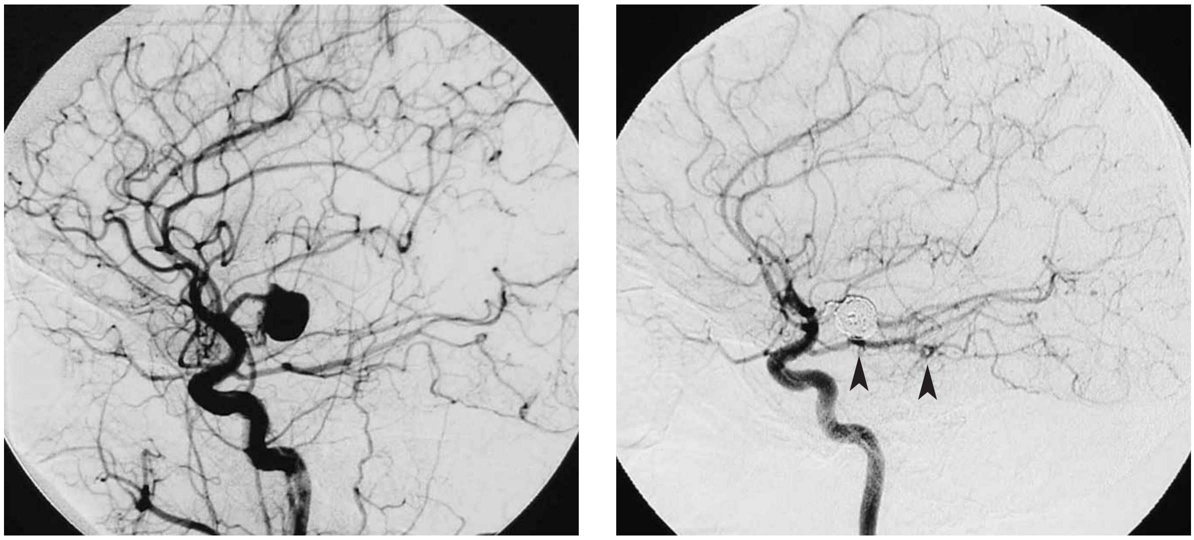

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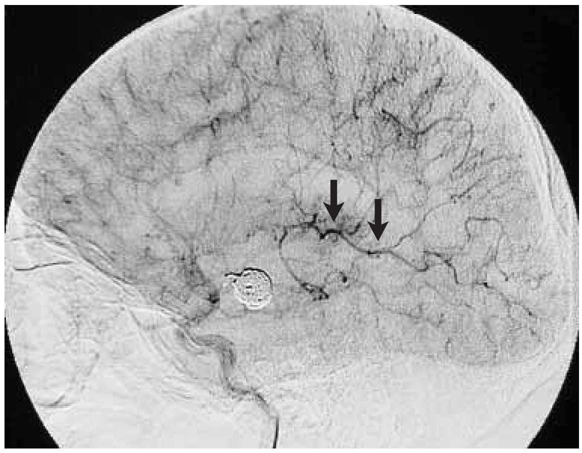

Figure 3 51-year-old woman suffering from headache. A) Lateral left internal carotid arteriogram. A saccular aneurysm of angular artery branch of MCA oriented inferiorly is seen. B) Postembolization left carotid injection, lateral view shows occlusion of the aneurysm with slow flow and filling of the parent artery (black arrowheads). C) Late-phase angiogram. Note the retrograde filling of the cortical branches of the parent artery (black arrows). D,E) Postembolization, T2-weighted axial images. Shows the signal characteristics of thrombosed aneurysm and hemosiderin ring around it (white arrow). No ischemic changes in the neural parenchyma is seen due to parent artery occlusion.

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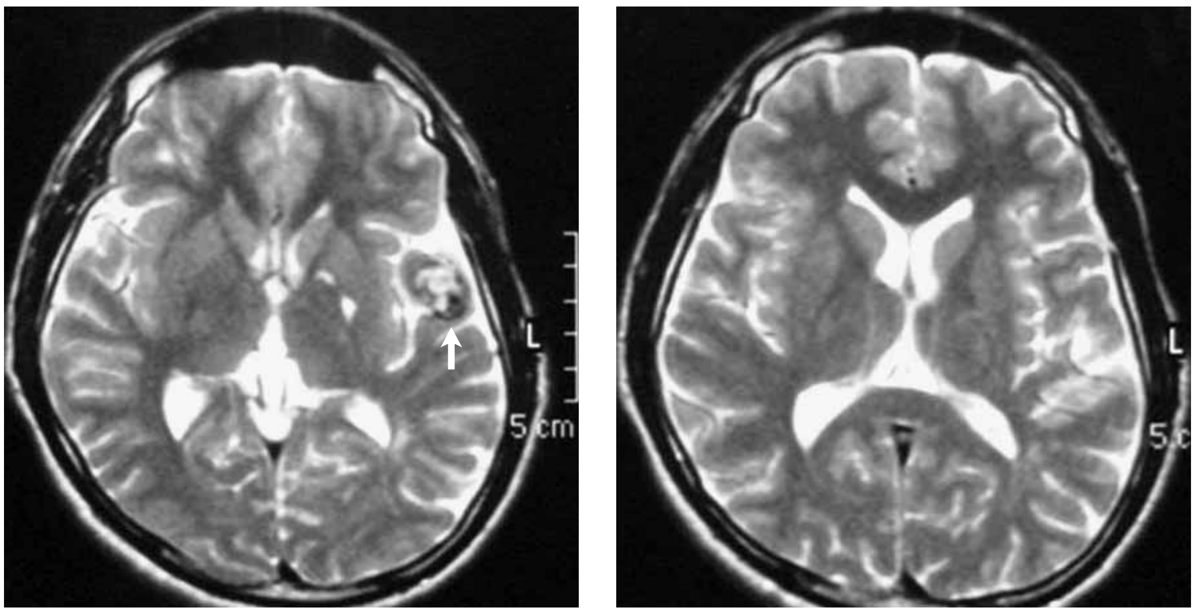

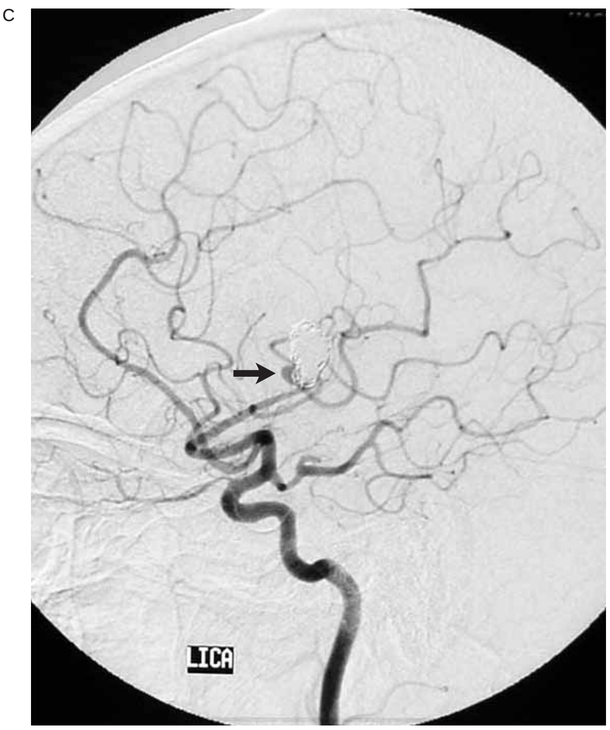

Figure 4 48-year-old woman presenting with subarachnoid haemorrhage. A,B) Pre- and post-embolization, lateral, left carotid injections show superiorly oriented saccular aneurysm of the angular artery of MCA and its total occlusion. C) Sixth-month control angiogram. A small re-growth is seen at the neck of the aneurysm (black arrow).

sion of the parent artery. The morphology of the aneurysm is another technical limitation and the presence of a wide neck, as in two of our cases, is the most important drawback. Since these aneurysms are distally located and the size of the arteries are small, it is hard to use the balloon remodeling technique. Therefore, in cases where the parent artery could not be spared, the treatment was accomplished with the occlusion of aneurysmal sac together with the parent artery.

In our view, branch occlusion by itself however, may not be sufficient without closure of the aneurysmal sac or the fusiform aneurysmal segment because the occluded artery can be filled in a retrograde fashion. Although this is a slight probability, it can cause the aneurysm to bleed, a commonly reported scenario seen in patients with dissecting aneurysms of the posterior circulation[23]. Another possibility is that the stagnant flow within the aneurysm can be a source for emboli.

We did not perform amytal test in fusiform aneurysm since the result would not change the treatment decision or modality. The test could be performed in saccular aneurysms to preserve the parent artery, but we thought that the deep penetration of amobarbital would overpredict the possible neurological deficit. When the vessel is actually occluded, collaterals may partially bypass the occlusion, which accounts for the discrepancy. This was the reason for us not performing the amytal test in saccular aneurysms either. Balloon test occlusion is the best physiological way to predict neurological deficit after parent artery occlusion. The distal location and the small size of the distal vascular bed, however, makes this procedure more difficult.

In our cohort, only one patient with a saccular aneurysm treated with selective aneurysm occlusion developed mild transient sensorial dysphasia. None of the other patients developed any additional neurological deficits in their early postoperative period or during follow-up.

Conclusions

Coil embolization is a safe and effective technique for the treatment of distal MCA aneurysms. The main objective for the endovascular treatment of distal intracranial aneurysms is the embolization of the aneurysm itself whether the aneurysm is fusiform or saccular in shape. The elimination of a fusiform aneurysm from the circulation results in the occlusion of the parent artery. On the other hand, preservation of the parent artery is preferred in saccular aneurysms, but this goal cannot be achieved in all cases. When the parent artery cannot be preserved, leptomeningeal collaterals generally provide adequate blood supply to prevent consequent neurological deficits.

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