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Yong Cheol Lim, M.D.
Yong Sam Shin, M.D., Ph.D.
Joonho Chung, M.D.

Department of Neurosurgery
School of Medicine
Ajou University
Suwon, Korea

Combined Endovascular and Microsurgical Procedures as Complementary Approaches in the Treatment of a Single Intracranial Aneurysm

Objective : Both endovascular coil embolization and microsurgical clipping are now firmly established as treatment options for the management of cerebral aneurysms. Moreover, they are sometimes used as complementary approaches each other. This study retrospectively analyzed our experience with endovascular and microsurgical procedures as complementary approaches in treating a single aneurysm.
Methods : Nineteen patients with intracranial aneurysm were managed with both endovascular and microsurgical treatments. All of the aneurysms were located in the anterior circulation. Eighteen patients presented with SAH, and 14 aneurysms had diameters of less than 10 mm, and five had diameters of 10-25 mm.
Results : Thirteen of the 19 patients were initially treated with endovascular coil embolization, followed by microsurgical management. Of the 13 patients, 9 patients had intraprocedural complications during coil embolization (intraprocedural rupture, coil protrusion, coil migration), rebleeding with regrowth of aneurysm in two patients, residual sac in one patient, and coil compaction in one patient. Six patients who had undergone microsurgical clipping were followed by coil embolization because of a residual aneurysm sac in four patients, and regrowth in two patients.
Conclusion : In intracranial aneurysms involving procedural endovascular complications or incomplete coil embolization and failed microsurgical clipping, because of anatomical and/or technical difficulties, the combined and complementary therapy with endovascular coiling and microsurgical clipping are valuable in providing the best outcome.

KEY WORDS : Cerebral aneurysm · Clipping · Coil embolization · Complementary therapy.

INTRODUCTION

During the past decade there has been a significant evolution in the nature of endovascular treatment for intracranial aneurysms. Indeed, both endovascular coil embolization and microsurgical clipping are now firmly established as treatment options for the management of cerebral aneurysms. Moreover, they are sometimes best used as complementary approaches in treating complex intracranial aneurysms and in the management of endovascular complications or failed microsurgical clipping[17-20].

In this report, we review our experience using a combination of microsurgical clipping and endovascular coil embolization in the management of a single aneurysm.

MATERIALS AND METHODS

We retrospectively reviewed information on consecutive patients with aneurysms treated with microsurgical clipping and/or endovascular treatment at our institution between March 2001 and December 2006. A total of 365 coil embolization procedures and 616 surgical clippings were performed in treating 981 aneurysms in 836 patients during this time period.

All patients who were treated with combined therapy involving microsurgical clipping and endovascular coil embolization for a single aneurysm were evaluated in this study. We excluded patients who were treated with attempted endovascular coiling and failed microsurgical clipping. These criteria lead to the inclusion of 19 aneurysms (1.94%) in 19 patients (2.27%). There were 10 males and 9 females ranging in age from 37 to 70 years (mean, 51.53 years).

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• Address for reprints :
Yong Sam Shin, M.D., Ph.D.
Department of Neurosurgery
School of Medicine, Ajou University
5 San, Woncheon-dong
Yeongtong-gu, Suwon 442-721, Korea
Tel : +82-31-219-5235
Fax : +82-31-219-5238
E-mail : nsshin@ajou.ac.kr

Eighteen patients presented with ruptured aneurysms. The clinical grade of the ruptured aneurysms included Hunt and Hess grade II in 6 cases, grade III in 7 cases, grade IV in 4 cases, and grade V in 1 case. Clinical summaries of their information are provided in Table 1 and 2.

All aneurysms were located in the anterior circulation. The most common aneurysm locations were the anterior (n=6) and posterior communicating arteries (n=6). The remaining seven aneurysms were located in the paraclinoid segment of the ICA (n=2), the MCA (n=2), the anterior choroidal artery (n=2), and the ICA bifurcation (n=1). Fourteen aneurysms had diameters of less than 10 mm, and five had diameters of 10 to 25 mm. The patients were followed for 10 to 78 months (mean, 29 months).

RESULTS

Clipping after coil embolization

Thirteen patients were initially treated with endovascular coil embolization and followed by microsurgical management (Table 1). The aneurysm sites were the posterior communicating artery (n=5), the anterior communicating artery (n=4), the anterior choroidal artery (n=1), the MCA (n=2), and the ICA bifurcation (n=1).

Six of these 13 patients had experienced aneurysm rupture during coil embolization. To make matters worse, during the insertion of further coils into the aneurysmal sac, 4 patients of them had additional procedure-related complications such as coil stretching, coil mass protrusion or prolapse into parent artery (cases 1, 2, 6, 8, 9), (Fig. 1). In four patients, there were protrusions or prolapses of the placed coil and occlusions of the parent artery (cases 2, 3, 7, 8). In cases 2, 3 with a small and saccular aneurysm, there were occlusions of the MCA by the placed coil. In case 7, in which the aneurysm was saccular in shape and superior-posterior in direction, there was protrusion of the coil into the ICA bifurcation and evidence of thromboembolism in the MCA. In case 8, there

Table 1. Clinical summary of patients treated with microsurgical clipping after coil embolization

No.	Sex/Age (year)	Location	Size (mm)	H&H grade	Causes of clipping after coiling	GOS	F/U (mo)
1	M/51	ACho	9×5	IV	Intraprocedural rupture, coil stretching	5	78
2	M/42	M1	4×4	III	Intraprocedural rupture, coil protrusion	5	68
3	F/63	MCA bif.	3×3	II	Coil prolapse	5	67
4	M/48	PCom	2×2	IV	An. regrowth	5	55
5	F/52	PCom	8×7	II	An. regrowth	5	29
6	M/39	PCom	4×2	II	Intraprocedural rupture, coil stretching	5	29
7	M/68	ICA bif.*	6×3	0	Coil prolapse	5	27
8	M/48	ACom	17×15	V	Intraprocedural rupture, coil protrusion	3	26
9	F/50	PCom	13×5	III	Intraprocedural rupture, coil stretching	4	19
10	M/51	ACom	3×2	II	Coil migration	5	17
11	M/45	ACom	4×2	III	Intraprocedural rupture, incomplete occlusion	5	14
12	F/55	PCom	9×6	III	Coil compaction	5	11
13	M/43	ACom	11×6	III	Residual sac	5	10

*Indicates unruptured aneurysm; An : aneurysm; ACho : anterior choroidal artery; ACom : anterior communicating artery; An : aneurysm; H&H grade : Hunt and Hess grade; GOS : Glasgow Outcome Scale; ICA bif. : internal carotid artery bifurcation; MCA bif. : middle cerebral artery bifurcation; PCom : posterior communicating artery

Table 2. Clinical summary of patients treated with coil embolization after microsurgical clipping

No.	Sex/Age (year)	Location	Size (mm)	H&H grade	Causes of coiling after clipping	GOS	F/U (mo)
14	F/37	Paraclin. ICA	3×3	II	An. regrowth	5	26
15	F/70	PCom	6×4	II	Clip slippage	4	20
16	F/56	Paraclin. ICA	14×10	IV	An. regrowth	4	19
17	F/60	ACom	10×8	III	Residual sac	5	13
18	M/56	ACom	5×5	III	Residual sac	3	12
19	F/45	ACho	4×3	IV	Residual sac	5	11

Paraclin. indicates Paraclinoid

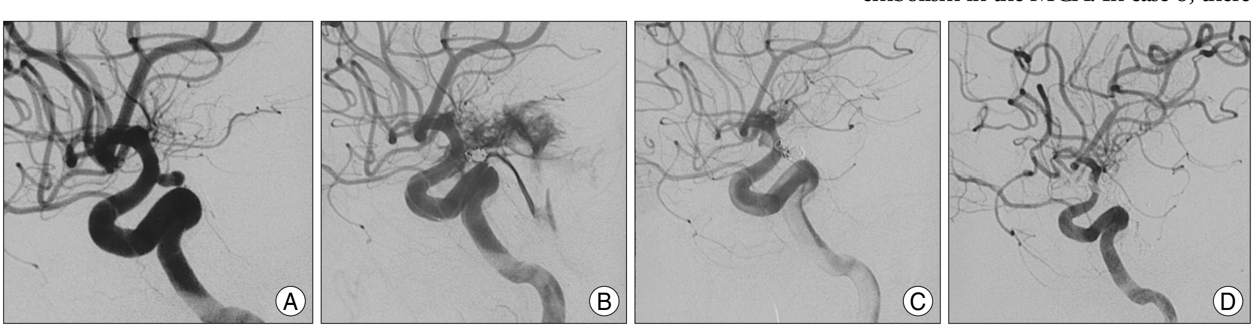

Fig. 1. Case 6. A 39-year-old man after subarachnoid hemorrhage from a right posterior communicating artery aneurysm. A : Right internal carotid artery angiogram demonstrating a 4×2 mm posterior communicating artery aneurysm. B : Angiographic image obtained with an injection through the guiding catheter in the right internal carotid artery demonstrating filling of the aneurysm neck and extravasation of contrast material. C : During further insertion of an additional coil, a stretched coil extending from the coil pack into the more distal internal carotid artery and extravasation of contrast material can be seen. D : Postoperative right internal carotid angiogram : the stretched coil was removed, and the aneurysm was clipped beneath the coil mass.

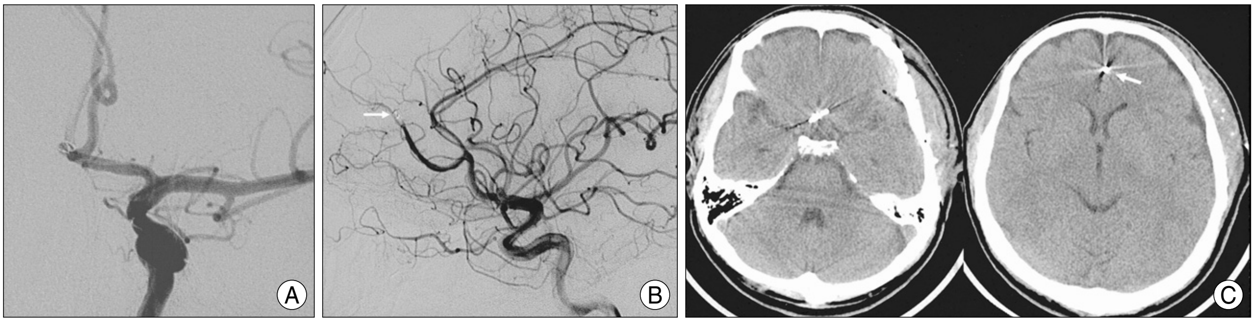

Fig. 2. Case 10. A 51-year-old man after subarachnoid hemorrhage from an anterior communicating artery aneurysm. A : Angiographic image obtained with an injection through the guiding catheter in the left internal carotid artery undergoing endovascular coil embolization. B : A coil mass has migrated into the callosomarginal branch of the anterior cerebral artery (arrow), although the patient was neurologically intact. C : The patient underwent aneurysm clipping without coil removal (arrow), because he had no neurological deficit.

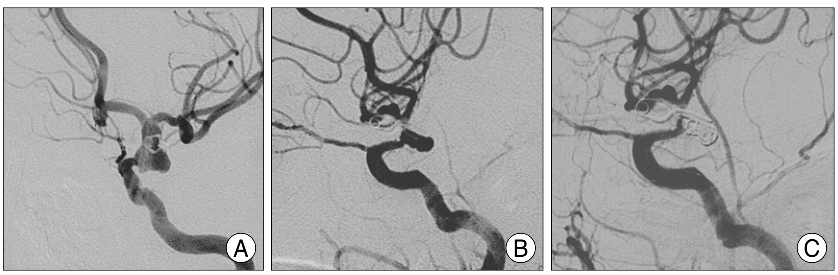

Fig. 3. Case 15. A 70-year-old woman who had had a posterior communicating artery aneurysm clipped 14 years prior to presenting with a recurrent aneurysm. A : Left internal carotid angiogram showing a 6×4 mm aneurysm sac. B : Left internal carotid angiogram after clipping of the aneurysm shows the residual aneurysm sac. C : Left internal carotid angiogram after placement of coils within the residual aneurysm sac, achieving complete occlusion.

was evidence of partial occlusion of the A2 segment of the ACA with breakage of the coil and protrusion. These patients underwent emergency craniotomy and the aneurysms were opened, and the coils were removed before direct clipping.

In one patient (case 10), coil migration occurred during the endovascular procedure. The aneurysm was a small anterior communicating artery aneurysm (3×2 mm) and superior-posterior in direction. The coil mass migrated into the callosomarginal branch of the ACA, but the patient was neurologically intact. The patient underwent surgical exploration with direct clipping of the aneurysm neck without removal of the migrated coil (Fig. 2).

In three cases, aneurysm regrowth and coil compaction after coil embolization were found in routine follow-up angiography (case 4, 5, 12). These patients underwent microsurgical retreatment after a signed consent form was obtained from patient and legal guardians.

In case 11, this patient had multiple aneurysms; anterior communicating artery and paraclinoid ICA aneurysms. The patient attempted coil embolization for all the aneursyms. Coil embolization was technically difficult, because of broad-necked, bi-directed pointing, anterior communicating artery aneurysm. The patient was initially treated with partial aneurysm coil packing. Staged microsurgical clipping was then performed.

Coil embolization after microsurgical clipping

Six patients who had undergone microsurgical clipping were followed by coil embolization (Table 2). Aneurysm locations were the anterior communicating artery (n=2), the paraclinoid ICA (n=2), the posterior communicating artery (n=1), and the anterior choroidal artery (n=1).

Four of these aneurysms had residual sac. The aneurysms were located in the anterior communicating artery (n=2), and the posterior communicating artery (n=1), and the anterior choroidal artery (n=1). The two anterior communicating artery aneurysms and the anterior choroidal artery aneurysm had multi-lobulated, and multiple point direction. They could not be clipped completely because of complex aneurysmal morphology and severe brain swelling. These residual aneurysms were treated successfully with endovascular coiling. One patient (case 15) had a posterior communicating artery aneurysm clipped 14 years previously before presenting with a recurrent aneurysm. This patient underwent reclipping, but the aneurysm was incompletely clipped due to broad neck, and a remnant neck was identified on immediate postoperative angiography. The aneurysm was then completely occluded by endovascular coiling (Fig. 3).

Two aneurysms had early regrowth of aneurysmal sac (case 14, 16). These patients had the paraclinoid ICA aneurysm, rebleeding occurred 2 weeks (case 14), and 1 month (case 16) after clipping. Early regrowth of aneurysmal sac was identified on angiography. Obliteration of the aneurysms was achieved by coil embolization.

Clinical outcomes

According to the Glasgow Outcome Scale, a 'good' recovery was achieved in 14 of the 19 patients, but two patients who underwent microsurgical clipping after an endovascular procedure experienced moderate and severe disabilities caused by symptomatic vasospasm and severe brain swelling. In three of the 6 patients who underwent an endovascular procedure after microsurgical clipping, moderate and severe disabilities occurred as a result of symptomatic vasospasm after rebleeding and thromboembolism during the endovascular procedure.

DISCUSSION

In 1995, endovascular treatment of surgically high-risk intracranial aneurysms using Guglielmi detachable coils (GDCs) was approved by the United States Food and Drug Administration (FDA). Since then, there has been a significant evolution in the nature of endovascular treatment for intracranial aneurysms. Endovascular coil embolization was established as treatment option for the management of cerebral aneurysms, especially since the completion of the International Subarachnoid Aneurysm Trial (ISAT)[22].

Endovascular coil embolization and microsurgical clipping are now both firmly established as treatment options for the management of intracranial aneurysms. Moreover, they are sometimes best used together in a complementary approach to complex intracranial aneurysms, especially those with periprocedural endovascular complications and/or failed microsurgical clipping.

Microsurgical solutions to periprocedural problems of coil embolization

Complications associated with intraprocedural coil embolization of intracranial aneurysms have been reported in many retrospective studies[2,4,6,8,13,14,16,21,23,24,26,27,29]. The common procedural complications are aneurysm rupture, coil protrusion or migration, thromboembolic events, and vessel dissection.

Periprocedural aneurysm rupture is a well-described event and may cause to death from an increase of ICP[8,16,20,26,34]. Several factors and mechanisms have been proposed, including smaller aneurysms, tortuosity of the arteries, and operator experience. The perforation of an aneurysm may occur by microcatheter perforation, guide wire perforation, coil penetration, and high-pressure contrast dye injection[20,26,29]. Following a perforation, it has been generally proposed that there be immediate reversal of anticoagulation, that the perforating device not be pulled out, and that further coils be inserted into the aneurysmal sac by placing a second microcatheter to complete the embolization[34]. However, the consequences of complex intraprocedural rupture, failed further coil insertion, or coil stretching or breakage have not been extensively described. Microsurgical management of the unsuccessful obliteration of aneurysms with endovascular maneuver has been reported[3,5,13,27].

Coil mass protrusion and migration into the parent artery are one of the most dread complications[8,24,25]. These complications can occur during treatment of wide-neck aneurysms, small aneurysms with size mismatch[8,25].

Following a protrusion of coils, it has been proposed several rescue endovascular procedures that the retrieval of protruded coils after snaring of the prolapsed strand[7], the inflation of a nondetachable microballoon in front of the aneurysm orifice[30], and the stent deployment in the protruded portion of the parent artery[15]. Despite these endovascular maneuvers, when the coil protrusion still occurs or the coil retrieval is failed, microsurgical management is required[5,33].

Our cases required microsurgical solutions had complex problems such as inaccessible rescue endovascular treatment (a second microcatheter could not be achieved to ruptured aneurysm), additional complications occurred such as coil protrusion and stretching. With intraprocedural aneurysmal rupture with coil protrusion and/or parent artery occlusion with prolapsed coil, the aneurysm was clipped with removal of coil mass (Fig. 1).

Endovascular retreatment after microsurgical clipping

A residual aneurysm after clipping is usually the result of technical or anatomical difficulties (*e.g.,* inadequate access, fusiform morphology, branch arteries at the base of the aneurysm), clip slippage, or regrowth of an aneurysmal sac[9,12,17]. The overall incidence of residual aneurysm after microsurgical clipping has been reported to be approximately 4 to 7%, and the regrowth rate of incompletely clipped aneurysms is approximately 7%[10,28,32]. Furthermore, some patients present with repeated subarachnoid hemorrhage or mass effect in the long-term follow up. Repeating the angiography after clipping has been recommended to confirm the complete obliteration of the aneurysm.

Owing to possible scar adhesions and a compromised aneurysmal neck position from a previous operation and clipping, reclipping of a residual aneurysm can present a higher risk and greater technical difficulty than the initial operation[9,12]. Consequently, endovascular management has been used in dealing with a residual aneurysm after a previous clipping[1,11,29,31]. We have experienced four cases of residual aneurysm and two cases of regrowth after clipping, and we have achieved aneurysm obliteration using complementary endovascular coil embolization.

CONCLUSION

We describe our experiences in patients who underwent combined treatment with endovascular coiling or incomplete coil embolization and microsurgical clipping of a single aneurysm. These aneurysms involved periprocedural endovascular complications or failed microsurgical clipping owing to anatomical or technical difficulties. A combined or intentional approach with endovascular coiling and microsurgical clipping may be valuable in providing the optimal treatment of intracranial aneurysms with technical and/or anatomical difficulties.

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