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Original Article

# Combined Endovascular and Microsurgical Hybrid Management of Cerebral Aneurysms: The Preliminary Fujita Experience


## Abstract

**Introduction:** A subgroup of complex aneurysms demands multimodal treatment by microscopic and endovascular means. Partial obliteration or remnant postprocedure demands to go further to the other modality. **Materials and Methods:** All patients between July 2016 and January 2017 who had to undergo multimodality measures for complete obliteration of the aneurysms were included in the study. The patients who had either undergone clipping or coiling for their aneurysms, but with incomplete obliteration of the aneurysm, were also included in the study. **Results:** Between July 2016 and January 2017, a total of three patients had to undergo coiling after clipping of the aneurysm for complete obliteration. Two patients had to go for clipping following coiling. All five patients had complete obliteration of the aneurysm sac. **Conclusion:** Both microscopic and endovascular means are complementary measures instead of competing procedures. It is important to realize the technical difficulties when surgical therapy follows initial endovascular treatment. Similarly, coiling a previously clipped aneurysm can be difficult, if the clip obscures normal working projections.


**Keywords:** *Clipping, coiling, endovascular, microscopic*


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## Introduction

Cerebral aneurysms are the leading cause of nontraumatic subarachnoid hemorrhage (SAH) and account for 70%–80% of SAH cases.[1] Untreated ruptured cerebral aneurysms are associated with a high mortality and a risk of rebleeding.[2] A large part of cerebrovascular neurosurgery is directed toward the diagnosis and treatment of aneurysms before they rupture. Microsurgical clipping and endovascular coil embolization are the two main treatment strategies for the obliteration of ruptured and unruptured aneurysms.

Complete exclusion rates with endovascular coiling are reported as 40%–55%, while the near complete exclusion rates are an additional 35.4%–52%.[3] Given improvements in both microsurgical clipping and endovascular therapy, both therapies are effective if used in the correct clinical setting.

The decision to triage patients for surgery and/or endovascular treatment benefits greatly from a multidisciplinary approach in the interest of patient outcome. For most aneurysms, a single well-chosen treatment modality has clear advantages and ensures adequate aneurysm protection. This is less straightforward for a subgroup of complex aneurysms although it requires multimodal treatment.

In this article, we present our experience of combined management of aneurysms by both microsurgical and endovascular procedures.

## Materials and Methods

Cerebral aneurysm patients were reviewed over a period between July 2016 and January 2017 at the Fujita Health University, Banbuntane Hotokukai Hospital, Nagoya, Japan. A retrospective analysis of all patients with unruptured cerebral aneurysms was performed. Patients' demographic data, site of the aneurysm, operation notes, and postoperative morbidities or mortalities were reviewed and recorded. Institutional ethical clearance and patient's consent for publication were taken for the same. According to our department protocol, all patients diagnosed with unruptured cerebral aneurysms who are candidate for treatment, will be discussed with neurointervention team of our department. If not considered a good candidate for intervention, the patient will be offered


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surgery. We use reconstructed computed tomography (CT) angiography routinely for surgical planning and in case of any ambiguity request a digital subtraction angiography. In our hospital, all neurovascular surgeries are performed with OPMI Pentero Microscope (Carl Zeiss, Oberkochen, Germany) with infrared 800 camera equipped with FLOW 800 software (Carl Zeiss, Oberkochen, Germany). On exposure of aneurysm, we perform indocyanine green videoangiography (ICG-VA) to clarify the aneurysm and its relation to all the surrounding vessels. Furthermore, to evaluate any perforating artery or other structures hidden behind the aneurysm, we introduce a rigid endoscope (Machida, Japan) under microscopic guidance. With this technique, we check for the estimated final location of the aneurysm clip tips to be away from any critical structure.

From July 2016 to January 2017, five such patients were identified who had either undergone coiling after clipping or clipping after coiling. Operative summaries, angiograms, and operative and ICG-VA videos were reviewed. The number, size, and location of aneurysms, the ICG-VA and IA findings, and the need for clip adjustment after ICG-VA and IA were recorded. Whenever the distal blood flow is in question, blood flow measurements with Doppler ultrasound (DVM 4300, Hadeco, Japan) and FLOW 800 software are made. Once again, the endoscope is used to check for the final position of the blades and their relations to other structure and also to make certain that the aneurysm neck is completely obliterated.

Following the procedure, an angiography brain was performed on the 2nd day and any remnant, if any were analyzed. The images were discussed between interventional surgeons and neurosurgeons. The best possible management was then provided to the patient if any remnant in the aneurysm was found.

On the other side, if the aneurysm was better suited for an endovascular procedure, the neurointerventional surgeon would primarily coil it, which was followed by a CT angiography with a three-dimensional (3D) reconstruct. In the presence of misplaced or displaced or partially obliterated aneurysm, the decision of going for open surgery or recoiling was made.

## Results

Between July 2016 and January 2017, three patients had to undergo coiling after clipping. There were two females and one male patient. Both female patients had the right internal carotid (IC) artery aneurysms of size 12 mm × 4 mm and 5 mm, respectively. The remnant was still present following clipping. The first patient underwent coiling and the second had stent-assisted coiling. Both had a repeat angiography after 6 months, showing complete obliteration of the aneurysm. One male patient was 50 years old who had two aneurysms on the left middle cerebral artery (MCA) and one on the right MCA. Both MCA aneurysms on the left side were clipped, due to subarachnoid hemorrhage on the left side. However, due to remnant aneurysm, coiling of left proximal MCA aneurysm was again performed.

Two patients had to undergo clipping after the first endovascular coiling procedure. One was a female of 44 years and the other, a male patient aged 60 years. The female patient had a left aneurysm in internal carotid artery-posterior communicating artery junction and coiling was done at an outside hospital. Follow-up angiography showed incomplete obliteration and clipping was performed. The male patient had distal A2–A3 and a basilar top aneurysm. Coiling was done for distal A2–A3 aneurysm at another hospital. Follow-up angiography showed incomplete obliteration. Interhemispheric approach for clipping of the residual A2–A3 aneurysm along with basilar top coiling was done at our hospital.

## Discussion

Microsurgical clipping requires the completion of a precise skull-base approach that provides safe access to the aneurysm and allows a microsurgical clip to be placed across its neck. A successful operation depends on a carefully thought-out plan comprising craniotomy, skull-base drilling, dural exposure, arachnoid dissection, and ultimately dissection of the aneurysm and its surrounding blood vessels. These steps require microsurgical finesse and are challenging in patients with ruptured aneurysms and cerebral edema. Appropriate brain relaxation is crucial and attempts are made to minimize brain retraction while approaching the circle of Willis at the skull base. Microsurgical treatment requires a craniotomy and is avoided in high risk and poor-grade SAH patients from a ruptured aneurysm, owing to prolonged brain retraction, difficulty of vessel dissection, and the need for longer anesthesia. More hemodynamic changes during microsurgical clipping and brain manipulation occur when compared to endovascular treatment. Postoperative cerebral blood flow and cerebral metabolic rate for oxygen may be decreased in the postoperative period secondary to brain retraction.[4,5]

The surgical approach is often limited in providing a 360° view of the aneurysm and associated perforators. In complex aneurysms, part of the aneurysm neck may be hidden from view, resulting in residual aneurysm filling after the aneurysm neck is clipped.[3] Aneurysms in the posterior circulatory system are less accessible than those in the anterior circulation and sometimes require extensive cranial base approaches that are invasive and associated with high morbidity.[6] This is especially true for posterior cerebral artery P2 segment, basilar trunk, proximal anteroinferior cerebellar artery, vertebrobasilar junction, and vertebral artery aneurysms where endovascular therapy is preferred.[7] Again, blister aneurysms <3 mm can be challenging when a sufficiently small clip is unavailable to clip the aneurysm without compromising the parent vessel. They do not have well-defined necks and have fragile walls making it difficult to clip primarily.[8] Repeat surgery for aneurysms that develop in a patient with a prior craniotomy is often challenging due to scar tissue, cerebral spinal fluid leaks, and previously placed clips that prevent a clear view of the aneurysm site. Aneurysms embedded in brain tissue, such as the brain stem and deeper structures, can be challenging to treat surgically as they involve dissection and possible injury to adjacent brain tissue during the clipping process,[9] resulting in permanent morbidity.

Successful endovascular coiling depends on adequate packing of the aneurysm dome and base with coils. A high dome-to-neck ratio is crucial in retaining coils inside the aneurysm. A narrow neck allows primary coiling of the aneurysm with resultant aneurysm thrombosis and protection. A wide neck can preclude tight packing of coiling and is associated with a high risk of coil prolapse into the parent vessel.

In complex wide-based aneurysm morphologies, a number of adjuncts may be used to promote a stable coil construct. This includes the use of compliant balloons to help remodel the coil construct to prevent coil prolapse.[10] Use of stent-assisted coiling requires antiplatelet agents, and thus cannot be safely used in most ruptured aneurysm situations.[11] Double microcatheter techniques can sometimes be used to achieve stable coil constructs in multilobed complex aneurysms by covering recesses with coils from two separate microcatheters.[12] More recently, flow diverters, such as pipeline and silk devices, have been used to treat wide-based complex aneurysms in the anterior circulation. These flow diverters allow vessel wall reconstruction and neointimal growth across the aneurysm neck with aneurysm exclusion over the ensuing months secondary to flow stasis inside the aneurysm. However, a rigorous dual antiplatelet regimen is employed in pipeline patients until the aneurysm is excluded.[13]

Endovascular coiling can be challenging in patients with tortuous vascular anatomy that makes access to the aneurysm difficult. Tortuosity in the aortic arch and neck can interfere with placement of the guide catheter, precluding safe delivery of the microcatheter to the aneurysm site. Thus, a complete coiling of the aneurysm is often not possible. Small parent vessels can sometimes pose a challenge to safe wiring and microcatheterization.

Endovascular coiling of aneurysms with important vessels that originate from the aneurysm dome or base may not be performed safely without compromising flow. In such cases, a partial coiling may be completed. While stent-assisted coiling and flow diverters may be used, they may pose an added risk to the patient treated with antiplatelet agents. In such a scenario, surgery offers the option of clip reconstruction of the aneurysm while preserving important perforators and bifurcation vessels.

Management of pseudoaneurysms with endovascular coiling is highly challenging due to the risk of increased vessel perforation with the placement of coils into the subarachnoid space. In such scenarios, endovascular sacrifice of the parent vessel may be necessary; otherwise, microsurgical trapping of the aneurysm is required. Similarly mycotic and traumatic distal aneurysms may not be approached safely with endovascular therapy. Coil mass extrusion is commonly observed when previously coiled patients are taken to the operating room. It could be misdiagnosed as compaction on angiography and is thought be a delayed process.

Microsurgical clipping allows protection of a large part of the aneurysm but, due to a limited surgical corridor and anatomical restraints, a part of the aneurysm may still continue to fill. In these situations, microsurgical clip reconstruction of the aneurysm can help create a narrow neck, which makes subsequent coil embolization of the residual aneurysm possible. This scenario is encountered in carotid cave and paraclinoid aneurysms where part of the aneurysm extends beyond the dural ring. This unique anatomy prevents placement of a microsurgical clip without dissection of the cavernous sinus, which can have significant morbidity. Reconstruction of a narrow neck allows easy coiling of the aneurysm. While neck reconstruction to favor coiling can help, it can alter flow dynamics with a higher flow jet toward the aneurysm dome increasing the likelihood of rupture in some cases. Therefore, second-stage coiling should be completed soon after clip reconstruction. Wrapping with neoveil may afford protection from rupture during subsequent coiling. Two of our patients with internal carotid artery aneurysms had to be coiled after clipping in this area, and one patient has to be clipped in the left MCA region, following remnant in angiography.

A coil embolization may be used as bailout in aneurysms with a highly calcified neck. Due to the presence of atherosclerotic calcified plaques, closure of the aneurysm neck may not be complete and a subsequent endovascular coil embolization of the aneurysm though the narrow calcified neck can help definitively thrombose the aneurysm. Another common situation for coil embolization after clipping is with aneurysm recurrences. Patients with an enlarging aneurysm residual can be safely treated with coiling, possibly with balloon and stent assistance.[14] This prevents the need for reoperation for a previously clipped aneurysm and avoids issues with scarring and high surgical risk. Kim *et al*. demonstrated safety of coiling partially clipped aneurysms in their series of 24 patients with residual/recurrent aneurysms postclipping. The only predictor of poor outcome in these cases was presentation with rerupture postclipping.[15]

Microsurgery in the setting of a ruptured aneurysm can be challenging due to hydrocephalus, brain edema, and altered cerebral hemodynamics. Coiling is thus better tolerated in the acute setting and with subsequent clipping if significant residual is present.[16,17] This situation may not be applicable to all aneurysms, especially blister and small aneurysms, which have a high risk of rupture with endovascular coiling.[18]

Civit *et al*. shared their early experience clipping ruptured aneurysms that were previously coiled in the acute stage. A good outcome was reported in this series that included partially coiled aneurysms, aneurysm recurrence, and/or rerupture after coiling.[19] In patients presenting with severe vasospasm, partial coiling followed by staged definitive clipping is a good algorithm to avoid microsurgical manipulation of vessels in the setting of vasospasm.[20] Rabinstein *et al*. reported a high incidence of vasospasm in SAH patients treated with clipping versus coiling.[21] The vasospasm treatment and coiling can be completed during the same procedure safely.

We had two patients who had to be clipped following coiling. One of them had an aneurysm in left internal carotid artery-posterior communicating artery junction and coiling was done at an outside hospital. Follow-up angiography showed incomplete obliteration, and clipping was performed. The other had distal A2–A3 and a basilar top aneurysm. Coiling was done for distal A2–A3 aneurysm at another hospital. Follow-up angiography showed incomplete obliteration. Interhemispheric approach for clipping of the residual A2–A3 aneurysm along with basilar top coiling was done at our hospital.

Waldron *et al*. reported their experience clipping previously coiled aneurysms. Partially coiled aneurysms are uncollapsible and difficult to manipulate. If coils extend to the aneurysm neck, they can hold the aneurysm walls apart and transform the soft neck into a wedge that can splay clip blades, causing a clip to slide down the neck and occlude parent and branch vessels. Coils can prevent complete closure of the neck and can extrude into the subarachnoid space to complicate the dissection of the aneurysm or branch arteries. Thrombus formation can harden an aneurysm and sometimes coils may have to be removed before safe clipping can be performed. In some cases, a bypass may be needed to safely remove coils and thrombus with clip reconstruction of the aneurysm. It is, however, advisable not to remove coils when possible.

## Conclusion

The authors consider microsurgical and endovascular therapies as complementary, rather than competing techniques for managing complex aneurysms. Improved surgical navigation systems, neurosurgical microscopes, microsurgery instrumentation, intraoperative ICG angiography, and intraoperative blood flow meters promote safe microsurgical clipping of aneurysms. In parallel, technological advancements in endovascular neurosurgery have brought the use of balloons, catheters, and stents, which effectively treat aneurysms with complex morphologies. All complex aneurysms should ideally be evaluated after a diagnostic cerebral angiogram with 3D reconstruction.

While it is beneficial to employ combined microsurgical and endovascular therapy for many complex aneurysms, it is important to realize the technical difficulties when surgical therapy follows initial endovascular treatment. For example, scarring may interfere with clipping a partially coiled aneurysm, and placing clips across the neck is more difficult if coils have prolapsed into the base, preventing complete clip closure. In addition, removing coils with surgical instruments to accommodate the clip may be hazardous. Similarly, coiling a previously clipped aneurysm can be difficult, should the clip obscure normal working projections. Issues surrounding antiplatelet therapy and heparinization need to be emphasized and microsurgical therapy must be appropriately timed with endovascular therapy.

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### Conflicts of interest

There are no conflicts of interest.

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