Treatment of Recurrent Intracranial Aneurysms After Clipping: A Report of 23 Cases and a Review of the Literature

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■ OBJECTIVE: **There are no established treatment strategies for aneurysms that recur after clipping. In this study, we present cases of patients who experienced recurrent aneurysms after clipping and subsequently underwent surgical intervention.**

■ METHODS: **Between 2004 and 2015, we surgically treated 23 aneurysms that recurred at a previously clipped site. Patient characteristics and clinical history were retrospectively reviewed.**

■ RESULTS: **Patients included 19 women and 4 men 45–81 years old. Aneurysms recurred 3–31 years (mean, 15.4 years) after the initial operation. For 18 cases, the first clinical presentation was a subarachnoid hemorrhage; aneurysms were incidentally diagnosed in 5 patients. Aneurysm locations were as follows: 9 on the internal carotid artery; 4 on the middle cerebral artery; 7 on the anterior communicating artery; 2 on the distal anterior cerebral artery; and 1 on the basilar artery. The reasons for retreatment included subarachnoid hemorrhage ($n = 9$) and aneurysm regrowth detected on follow-up examinations ($n = 14$). Endovascular treatment was performed in 10 cases, and direct surgery was performed in 13 cases (clipping in 8, clipping or trapping with bypass in 5). Various complex vascular reconstructions, including high-flow bypass and intracranial-intracranial in situ bypass, were performed for recurrent aneurysms.**

■ CONCLUSIONS: **In our experience, coil embolization is a safe and effective procedure for treating recurrent aneurysms. When cases are unsuitable for coil embolization, surgical treatment often requires neurosurgeons not only to overcome the general technical difficulty of reoperative clipping but also to perform challenging vascular reconstruction.**

INTRODUCTION

Several studies have reported aneurysm regrowth at a previously clipped site,[1-4] and de novo aneurysm formation after clipping is an occasional but well-established occurrence.[5,6] Recurrent aneurysms have been treated with endovascular procedures[7-11] and direct surgery,[5,9,10,12] but current reports have not discussed in detail the methods by which treatment procedures are chosen. Because the technical difficulties associated with reoperative procedures for recurrent aneurysms are well established,[5] some authors have suggested endovascular coiling as a safe and effective retreatment option.[7-11] Although progress in

Key words
- Bypass
- Cerebral aneurysms
- Clipping
- Coil embolization
- Recurrence

Abbreviations and Acronyms
3D: Three-dimensional
ACA: Anterior cerebral artery
AComA: Anterior communicating artery
CT: Computed tomography
DSA: Digital subtraction angiography
ECA: External carotid artery
ICA: Internal carotid artery
IC-IC: Intracranial-intracranial
IC-PC: Internal carotid artery–posterior communicating artery
MCA: Middle cerebral artery
mRS: Modified Rankin Scale
RA: Radial artery
SAH: Subarachnoid hemorrhage
STA: Superficial temporal artery
WFNS: World Federation of Neurologic Surgeons

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Citation: World Neurosurg. (2016) 92:434-444.
http://dx.doi.org/10.1016/j.wneu.2016.05.053

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

neuroendovascular procedures can make various complex aneurysms treatable,[13-15] there are some cases of aneurysms deemed unsuitable for coil embolization, such as thrombotic aneurysms, giant aneurysms, and wide neck aneurysms. For these cases, we have had to perform a craniotomy procedure. These operations often require neurosurgeons to overcome the technical difficulties associated with severe adhesions when establishing an approach route and to create space around the aneurysm. In this article, we present 23 patients who had a recurrent aneurysm after clipping and underwent surgical interventions. These cases are thoroughly reviewed with a focus on direct surgical management.

MATERIALS AND METHODS

The institutional review board approved this retrospective study; informed patient consent was not required. During the years 2004–2015, we performed 23 consecutive surgical procedures to treat saccular aneurysms that regrew at a previously clipped site. For patients with an aneurysm that required retreatment within 2 years after initial clipping, the initial treatments for these cases were regarded as having incomplete clipping, and the cases were excluded. Patient clinical records were reviewed for age and sex; aneurysm location, type, and timing; type of surgery performed for the second treatment; and surgical complications. Patients who presented with temporary or permanent neurologic deterioration and patients who required additional surgical therapy were regarded as having a surgical complication. Clinical outcomes were evaluated before and after second surgical procedures using modified Rankin Scale (mRS) scoring.

Endovascular treatment was initially considered in all recurrent aneurysms as an alternative treatment method. After discussion between neurovascular surgeons and neuroradiologists, the decision was made whether the recurrent aneurysm was suitable for endovascular treatment. The choice of treatment modality is mainly based on the overall complex architecture of the aneurysm (wide neck, large size, or incorporated vessel origins), not on age or subarachnoid hemorrhage (SAH) grade. Partially thrombosed aneurysms and aneurysms with intracerebral hemorrhage were treated by direct surgery.

RESULTS

Patient Characteristics

Case summaries are presented in **Table 1**. Patients were 23–66 years old (mean ± SD, 49.0 years ± 13.1) at their first admission and 45–81 years old (mean ± SD, 64.5 years ± 10.8) at their second admission. Of the 23 patients, 19 were women. Recurrent aneurysms occurred 3–31 years (mean ± SD, 15.4 years ± 7.0) after the first operation. In 18 patients, the first clinical presentation was SAH; aneurysm was incidentally diagnosed in 5 asymptomatic patients. Aneurysm locations were as follows: 9 at the origin of internal carotid artery–posterior communicating artery (IC-PC), 4 at the bifurcation of the middle cerebral artery (MCA), 7 on the anterior communicating artery (AComA), 2 on the distal anterior cerebral artery (ACA), and 1 on the basilar artery. The reasons for retreatment included SAH ($n = 9$) and aneurysm regrowth (>4 mm) detected on follow-up three-dimensional (3D) computed tomography (CT) angiography or digital subtraction angiography (DSA) ($n = 14$). All 14 patients with unruptured aneurysm were asymptomatic.

Procedure and Technical Adjuncts for Recurrent Aneurysms After Clipping

All second procedures for SAH were performed within 24 hours after SAH. Surgical complications were noted in 5 patients: cerebral infarction ($n = 3$), meningitis ($n = 1$), and status epilepticus ($n = 1$). There were 6 patients with mRS score that worsened. The reasons were initial brain damage in the patients with World Federation of Neurologic Surgeons (WFNS) grade 5 SAH (cases 10 and 20), cerebral infarction secondary to spasm (case 21), patient age and disabled state before second treatment (case 3), and cerebral infarction caused by treatment procedures (cases 9 and 23). Patient 9 experienced cerebral infarction as a result of thrombus from the coil 2 weeks after coil embolization despite taking 2 antiplatelet drugs, and she retained mild dysarthria (mRS score 0→1). Patient 23 experienced caudate head infarction just after clipping surgery and retained slight memory disturbance (mRS score 0→1).

Endovascular coil embolization was considered in all recurrent aneurysms as an alternative treatment method, and 10 patients received endovascular treatment (cases 1–10). All coil embolization procedures were performed by a simple technique, without using stents, flow diverters, and intrasaccular flow modifiers. The other 13 patients underwent direct surgery (cases 11–23) because they were deemed to be unsuitable for endovascular treatment after discussion with the neuroradiologist. Microsurgical neck clipping without bypass was performed in 8 cases (cases 11–18). For 6 of these 8 aneurysms (cases 11–16), new clipping was performed without the removal of the old clip. For 2 aneurysms (cases 17 and 18), the old clips were removed after being released from the surrounding adhesions, followed by reclipping of the new neck region. The remaining 5 patients (cases 19–23) underwent neck clipping, trapping, or proximal ligation with bypass surgery. One MCA aneurysm (case 19) was treated with clipping that included superficial temporal artery (STA)–MCA anastomosis because the preservation of MCA blood flow was deemed very difficult. Two IC-PC aneurysms (cases 20 and 21) were treated with high-flow bypass. In case 21, considering the prolonged intraoperative proximal temporary occlusion of the parent artery, we first performed external carotid artery (ECA)–radial artery (RA)–M2 segment of MCA (ECA-RA-M2) bypass. Then the adherent tissues around the aneurysm were dissected during proximal flow control because we found it impossible to perform complete neck clipping without removing the old clip. However, because of the presence of severe adhesions around the neck and the previous clip, it was decided that removal was too risky. Therefore, dome clipping of the rupture site was performed. After we confirmed the patency of the high-flow bypass, proximal internal carotid artery ligation was performed to prevent the clip from slipping out and the residual aneurysm from growing larger. One AComA broad neck recurrent aneurysm (case 22) was treated using trapping and A3-A3 with side-to-side in situ anastomosis to preserve right anterior cerebral artery (ACA) blood flow. One partially thrombosed giant distal ACA aneurysm (case 23) was treated with trapping