Risk of Aneurysm Residual Regrowth, Recurrence, and de Novo Aneurysm Formation After Microsurgical Clip Occlusion Based on Follow-up with Catheter Angiography

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■ INTRODUCTION: **Established guidelines for radiologic surveillance after microsurgical treatment of intracranial aneurysms are lacking in the literature because of small sample sizes, poor definitions, and heterogeneous use of imaging modalities. We aimed to propose clinically meaningful definitions for postoperative aneurysm residual, recurrence, and de novo aneurysm formation and to analyze our long-term follow-up catheter angiography results in patients with microsurgically treated intracranial aneurysms.**

■ METHODS: **A retrospective review of all aneurysms treated microsurgically in a consecutive, single-surgeon series from 1997 to present identified patients with long-term follow-up catheter angiography (>1 year after surgery). Clinical and radiologic data were collected for analysis.**

■ RESULTS: **We identified 240 patients harboring 380 aneurysms (mean follow-up time, 6.0 ± 3.3 years per patient; range, 1.0–16.8 years). Postoperative residuals were present in 16 out of 346 clipped aneurysms (4.6%), of which only 3 were left unintentionally. Two out of 16 residual aneurysms (12.5%) demonstrated regrowth, with a regrowth risk of 2.1% per year from 93.6 patient-years of angiographic follow-up. Of 326 aneurysms with no postoperative residual, 5 (1.5%) demonstrated aneurysm recurrence, with a recurrence risk of 0.26% per year from 1931.9 patient-years of angiographic follow-up. Eight de novo aneurysms were identified in 240 patients (3.3%), with a risk of 0.6% per year from 1441.9 patient-years of angiographic follow-up.**

■ CONCLUSIONS: **Microsurgically treated aneurysms have a very low risk of postoperative residuals and aneurysm recurrence. Growth of residuals and de novo aneurysm formation justify following up with catheter angiography 3 to 5 years after microsurgical clipping.**

INTRODUCTION

Currently, there are no established guidelines for radiologic surveillance after microsurgical treatment of intracranial aneurysms. Various groups have recommended long-term angiographic follow-up for patients with residual and/or multiple aneurysms,[1,2] but published studies have been limited by small sample size and relatively short follow-up periods,[2,3] which then lead to inaccurate estimations of the risk of aneurysm regrowth, recurrence, and de novo aneurysm formation. Although a recent report included 758 aneurysms with 5295.7 patient-years of radiologic follow-up with computed tomographic angiography (CTA) or catheter angiography,[1] verification of its findings is necessary because CTA has lower sensitivity (71%) and specificity (94%) for identifying residual and recurrent aneurysms than catheter angiography.[4,5] In addition to these sources of error, differences in reported regrowth, recurrence, de novo aneurysm formation, and hemorrhage rates could be due to interobserver variability. Moreover, the rarity of aneurysm regrowth, recurrence, and de novo aneurysm formation makes best practice recommendations difficult, especially working within the financial constraints of the healthcare system.

We have maintained a prospective database of intracranial aneurysms treated microsurgically at our center for 20 years. In this study, we aimed to propose and validate clinically

Key words
- Aneurysm recurrence
- Aneurysm regrowth
- Catheter angiography
- Microsurgical aneurysm clip occlusion
- De novo aneurysm formation

Abbreviations and Acronyms
ACoA: Anterior communicating artery
AVM: Arteriovenous malformation
CTA: Computed tomographic angiography
HH: Hunt and Hess grade
MCA: Middle cerebral artery
SAH: Subarachnoid hemorrhage

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Table 1. Patient and Aneurysm Characteristics (N = 240 Patients; N = 380 Aneurysms)

Characteristic	
Age (years)*	48.4 (11—73)
Gender	
Male	51 (21.2%)
Female	189 (78.8%)
Subarachnoid hemorrhage	90 (37.5%)
Multiple aneurysms	139 (57.9%)
Aneurysm size	
Large (≥10 mm)	52 (13.7%)
Giant (≥25 mm)	11 (2.9%)
Aneurysm location	
ACA	12 (3.2%)
ACoA	57 (15.0%)
AICA	1 (0.3%)
Anterior choroidal	15 (3.9%)
Basilar apex	16 (4.2%)
Basilar perforator	2 (0.5%)
Callosomarginal or pericallosal	12 (3.2%)
Cavernous ICA	7 (1.8%)
ICA bifurcation	9 (2.4%)
MCA	114 (30.0%)
Paraclinoid or supraclinoid ICA	34 (8.9%)
PCA	9 (2.4%)
PCoA	44 (11.6%)
PICA	10 (2.6%)
Ophthalmic	24 (6.3%)
SCA	9 (2.4%)
Superior hypophyseal	4 (1.1%)
Vertebral	1 (0.3%)
Aneurysm morphology	
Thrombotic	7 (1.8%)
Fusiform	32 (8.4%)
Dolichoectatic	8 (2.1%)
Recurrent or residual from prior coil embolization	16 (4.2%)
Recurrent or residual from prior microsurgical clipping	7 (1.8%)
Prior unsuccessful attempt at coil embolization	10 (2.6%)
Operative procedure	
Microsurgical clipping	339 (89.2%)
Microsurgical clip reconstruction	7 (1.8%)
Microsurgical clipping with immediate coil embolization	4 (1.1%)
Bypass and occlusion or trapping	18 (4.7%)
Residual after microsurgical clipping or clip reconstruction	
Subarachnoid hemorrhage	16 (4.6%)
Intentionally left	6 (37.5%)
Location of unintended residuals	13 (81.3%)
ACoA	1 (33.3%)
PCoA	1 (33.3%)
Supraclinoid ICA	1 (33.3%)
Size of residuals (mm)*	2.9 (2.0—6.0)
Intentional residuals (mm)*	2.9 (2.0—6.0)
Unintended residuals (mm)*	2.6 (2.0—3.4)

Continues

Table 1. Continued

ACA, anterior cerebral artery; ACoA, anterior communicating artery; AICA, anterior inferior cerebellar artery; ICA, internal carotid artery; MCA, middle cerebral artery; PCA, posterior cerebral artery; PICA, posterior inferior cerebellar artery; SCA, superior cerebellar artery; PCoA, posterior communicating artery.
*Numerical variables are reported as mean (range).

meaningful definitions for postoperative aneurysm residual, recurrence, and de novo aneurysm formation, and to document our experience with long-term follow-up for patients with microsurgically treated intracranial aneurysms using catheter angiography.

METHODS

Inclusion Criteria

This study was approved by the institutional review board and performed in compliance with Health Insurance Probability and Accountability Act regulations. A retrospective review of all

Table 2. Regrowth or Recurrence After Microsurgical Clipping or Clip Reconstruction of Intracranial Aneurysms

Outcome	No Postoperative Residual (n = 326)	Postoperative Residual (n = 16)	*P*
Regrowth or recurrence	5 (1.5%)	2 (12.5%)	0.0376
Size of regrowth or recurrence (mm)	1.9 (1.0—4.0)	2.0 (2.0—2.0)*	0.160
Latency to detection (years)	7.4 (3.5—12.3)†	4.8 (3.0—6.6)	0.571

*Difference in size between immediate postoperative residual and residual at angiographic follow-up.
†1 patient presented with subarachnoid hemorrhage from a 3.3-mm recurrence 9.3 years after initial treatment.