



Microsurgical Treatment of Previously Coiled Intracranial Aneurysms: Systematic Review of the Literature

Omar M. Arnaout¹, Tarek Y. El Ahmadieh², Samer G. Zammar¹, Najib E. El Teclé¹, Youssef J. Hamade³, Rami James N. Aoun³, Salah G. Aoun², Rudy J. Rahme¹, Christopher S. Eddleman², Daniel L. Barrow^{3,4}, H. Hunt Batjer², Bernard R. Bendok³

■ **OBJECTIVE:** To assess indications, complications, clinical outcomes, and technical nuances of microsurgical treatment of previously coiled intracranial aneurysms.

■ **METHODS:** A systematic review of the literature was performed using PubMed/MEDLINE and EMBASE databases from January 1990 to December 2013. English-language articles reporting on microsurgical treatment of previously coiled intracranial aneurysms were included. Articles that involved embolization materials other than coils were excluded. Data on aneurysm characteristics, indications for surgery, techniques, complications, angiographic obliteration rates, and clinical outcomes were collected.

■ **RESULTS:** The literature review identified 29 articles reporting on microsurgical clipping of 375 previously coiled aneurysms. Of the aneurysms, 68% were small (<10 mm). Indications for clipping included the presence of a neck remnant (48%) and new aneurysmal growth (45%). Rebleeding before clipping was reported in 6% of cases. Coil extraction was performed in 13% of cases. The median time from initial coiling to clipping was 7 months. The angiographic cure rate was 93%, with morbidity and mortality of 9.8% and 3.6%, respectively.

■ **CONCLUSIONS:** Microsurgical clipping of previously coiled aneurysms can result in high obliteration rates with relatively low morbidity and mortality in select cases. Considerations for microsurgical strategies include the

presence of sufficient aneurysmal tissue for clip placement and the potential need for temporary occlusion or flow arrest. Coil extraction is not needed in most cases.

INTRODUCTION

The endovascular treatment of intracranial aneurysms was first introduced by Serbinenko in 1974 (51) and has seen several major advancements since that time. As the widespread use of endovascular coiling continues to increase, so does the population of patients who require retreatment for incomplete occlusion or recurrence. The International Subarachnoid Aneurysm Trial (ISAT) reported a 34% combined rate of aneurysm subtotal occlusion and refilling after endovascular coiling (37). The Cerebral Aneurysm Rerupture After Treatment (CARAT) study reported annual retreatment rates of coiled aneurysms of 13.3%, 4.5%, and 1.1% during the first, second, and subsequent years (22). Although the natural history of previously coiled aneurysms with remnants and aneurysms demonstrating regrowth has not been fully elucidated (5, 22, 47, 55), significant residual aneurysm filling has been linked to hemorrhage and mass effect symptoms, particularly in previously ruptured aneurysms (6, 7, 49). Approximately one third of residual lesions show evidence of progressive growth, which may be an indication for retreatment (10, 19). At the present time, retreatment options for previously coiled intracranial aneurysms include repeat endovascular treatment, with or without adjunctive endovascular devices; microsurgical clipping; and parent artery

Key words

- Aneurysm recurrence
- Clip after coil
- Coil
- Intracranial aneurysm
- Microsurgery
- Recurrence

Abbreviations and Acronyms

CARAT: Cerebral Aneurysm Rerupture After Treatment

GOS: Glasgow Coma Scale

ISAT: International Subarachnoid Aneurysm Trial

ISUIA: International Study of Unruptured Intracranial Aneurysms

From the ¹Department of Neurological Surgery, Northwestern Memorial Hospital, Chicago, Illinois; ²Department of Neurological Surgery, University of Texas Southwestern Medical Center, Dallas, Texas; ³Department of Neurological Surgery, Mayo Clinic Hospital, Phoenix, Arizona; and ⁴Department of Neurological Surgery, Emory University School of Medicine, Atlanta, Georgia, USA

To whom correspondence should be addressed: Bernard R. Bendok, M.D., M.S.C.I.
[E-mail: bendok.bernard@mayo.edu]

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occlusion. Revascularization techniques may be needed when occlusion of a parent artery is planned. The evidence for microsurgical retreatment of previously coiled intracranial aneurysms is sparse, and guidelines are lacking. We aimed to review systematically the English-language literature on this issue with a focus on indications, complications, outcomes, and technical nuances.

MATERIALS AND METHODS

A search strategy was designed to identify relevant reports on microsurgical treatment of previously coiled intracranial aneurysms. The search was restricted to English-language articles published between January 1990 and December 2013. Articles were identified from PubMed/MEDLINE and EMBASE databases using the key terms “intracranial aneurysm,” “coil embolization,” “endovascular surgery,” “aneurysm recurrence,” and “surgical clipping.” Additional sources were identified from manual review of bibliographies of the retrieved articles. Studies were included if they reported on the use of microsurgical clipping to treat intracranial aneurysms with endovascular coils including at least 1 case report. Studies were excluded if: 1) embolization materials other than endovascular coils were used or 2) the indication for surgery was embolization failure with no coil deposition. Additionally, individual cases were excluded from analysis using the same exclusion criteria.

The reference list generated by the search was independently reviewed by 3 researchers to identify relevant reports, and the senior author (BB) resolved any conflicts. A data collection form was used to include initial aneurysm size, location, presentation, mean/median latency time to surgery, indication for surgery, whether patients underwent repeat endovascular treatment before surgery, surgical technique including the use of temporary clips and coil extraction, surgical complications, postsurgical angiographic obliteration rates, and clinical outcomes.

RESULTS

Epidemiology

We identified 27 articles; 1 was excluded for exclusively using embolization material other than coils (26), and 1 was excluded for overlapping patient data that were updated in a more recent publication (27). After manual review of bibliographies, 4 additional studies were identified (2, 21, 32, 55). The 29 studies that were included are listed in **Table 1** (2, 3, 6-8, 11, 12, 16-18, 21, 24, 25, 27, 29, 30, 32, 36, 39, 42, 46, 49, 50, 52-54, 56, 59, 61). **Table 2** summarizes data from the included series that reported on the total number of aneurysms treated endovascularly in a given institution and the percentage of patients who subsequently underwent surgical retreatment. The present study includes data from 375 aneurysms that were treated with microsurgical clipping after endovascular coiling. Most of the lesions were small (<10 mm), as shown in **Figure 1**, with a mean size of 8.9 mm. Approximately one third of lesions were anterior communicating artery aneurysms, and 90% of all lesions were located in the anterior circulation. The frequency of individual locations is summarized in **Figure 2**. The initial manifestation was hemorrhage in 80% of aneurysms. Of the total number of patients initially treated with an endovascular intervention in the

reviewed cohort, the mean percentage of patients who subsequently underwent surgical treatment of the same lesion was 6.8% (**Table 2**).

Indications for Surgery

The most common indication for surgical clipping was the presence of an aneurysmal remnant after endovascular treatment (50% of reviewed cases) followed by recanalization and regrowth of previously obliterated aneurysms (40% of cases). Rebleeding before microsurgical clipping was reported in 6% of cases (7, 11, 16, 24, 29, 30, 36, 49, 56). Other indications for surgery included mass effect and coil migration. The mean latency time between endovascular treatment and surgical clipping was 9.5 months, and the median was 6.9 months with a wide range spanning from a few hours to 9 years (21, 56). By contrast, in a study by Giannotta and Litofsky (15), the mean latency time from surgical clipping to symptomatic recurrence warranting reoperative management was between 9.75 and 10.5 years.

Surgical Technique

With respect to surgical technique, 46% of authors employed temporary clipping, and coils were extracted from approximately 13% of all aneurysms. When surgical clipping was not feasible, other techniques were employed, including aneurysm wrapping ($n = 10$; 2.7%), bypass ($n = 8$; 2.1%), trapping ($n = 7$; 1.9%), and ligation and coagulation ($n = 4$; 1.8%). Overall, 8.0% of cases could not be directly clipped and required the use of an alternative surgical strategy.

Clinical and Angiographic Outcome

The mean postsurgical angiographic obliteration rate was 93% with 42% of studies reporting 100% obliteration rates. The mean postsurgical Glasgow Outcome Scale (GOS) score was 4.55, which was largely unchanged from the pretreatment GOS score (when reported) (8, 56). Surgical complications included postoperative intracranial hemorrhage (1.33%), permanent neurologic deficit (2%), transient neurologic deficits (1%), intraoperative rupture (1%), and postoperative wound infection (1%). The total morbidity was 8.1%. There were 10 deaths reported resulting in a total mortality rate of 2.7%. Reported causes of death were sequelae of postcoiling, preclipping intracranial hemorrhage (3 cases; 1%), intraoperative rupture (15 cases; 4%), and intracranial bleeding in the immediate postoperative period (4 cases; 1.2%).

DISCUSSION

As endovascular coil embolization for the treatment of intracranial aneurysms has become more prevalent, the number of intracranial aneurysms requiring retreatment has increased (56). Indications for retreatment include incomplete obliteration, subsequent growth of residual neck or dome, and coil compaction resulting in fundal refilling (10, 21, 52). Incomplete aneurysm treatment associated with coil embolization as well as aneurysm recurrence may necessitate subsequent microsurgical treatment because of potential risk of subarachnoid hemorrhage and mass effect (34, 35, 58). Waldron et al. (56) reported a spike in the number of previously coiled aneurysms for which microsurgical management was performed in 2007, the most recent year of their study period, compared with previous years.

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