

# Outcomes of Oculomotor Nerve Palsy Caused by Internal Carotid Artery Aneurysm: Comparison between Microsurgical Clipping and Endovascular Coiling

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## Abstract

The purpose of this study was to compare the clinical outcomes of microsurgical clipping and endovascular coiling in patients with oculomotor nerve palsy (ONP) caused by internal carotid artery (ICA) aneurysm. Among 17 patients with ICA aneurysms presented with ONP, 9 (52.9%) underwent microsurgical clipping and 8 (47.1%) underwent endovascular coiling. Outcomes of functional recovery of ONP were investigated and compared between surgical group and endovascular group. Mean intervals between the onset and treatment were significantly longer in microsurgical group (18.2 days) than in endovascular group (3.5 days). In microsurgical group, complete resolution (CR) of ONP was obtained in 7 of 9 patients (77.8%) and partial resolution (PR) was seen in 2 patients (22.2%). In endovascular group, CR was obtained in 5 of 8 patients (62.5%) and PR was seen in 3 patients (37.5%). The optimal treatment of aneurysm-induced ONP remains controversial; however, present study suggests both procedures are beneficial for achieving functional recovery of ONP. The treatment strategy should be decided primarily considering the general risks of the two procedures, and presence of ONP is not a disadvantageous factor for either procedure.

Key words: oculomotor nerve palsy, internal carotid artery aneurysm, microsurgical clipping, endovascular coiling

## Introduction

Oculomotor nerve palsy (ONP) caused by internal carotid artery (ICA) aneurysm is a common clinical manifestation suggesting impending rupture or re-rupture of the aneurysm, and immediate treatment is strongly recommended to prevent bleeding. However, the best treatment strategy for functional recovery of the ONP remains controversial. Some authors insist the superiority of the microsurgical clipping regarding the immediate decompression of the oculomotor nerve.<sup>1–3</sup> On the other hand, reports of the endovascular treatment in these symptomatic aneurysms are recently increasing, demonstrating the safety and high efficacy of endovascular treatment for ONP recovery.<sup>4,5</sup>

We investigated the clinical outcome of aneurysm-induced ONP in 17 patients treated in our institution, to confirm the difference between microsurgical clipping and endovascular coiling from the viewpoints of prognostic factors of ONP recovery.

## Materials and Methods

Between 2003 and 2014, 206 patients with ICA aneurysms underwent microsurgical clipping or endovascular coiling, and of these, 17 (8.2%) presented with preoperative ONP. Nine of the 17 patients (52.9%) underwent microsurgical clipping and 8 patients (47.1%) underwent endovascular coiling (Table 1). Complete ONP was defined when patients showed the following features: ptosis, mydriasis, ophthalmoplegia, and diplopia. Complete resolution (CR) of ONP was defined as the disappearance of all of the above features. If any of the features persisted during the follow-up period, the functional outcome was defined as partial resolution (PR).

The functional outcomes of ONP were compared between the microsurgical group and the endovascular group. We assessed the factors that influenced the functional recovery of ONP. Statistical analyses were performed using Fisher's exact test and the Mann-Whitney *U* test, considering *p* values of < 0.05 significant.

**Table 1** Characteristics of the 17 patients with internal carotid artery aneurysm with oculomotor nerve palsy

Case	Age, sex	H&K grade	Onset to treatment (day)	ONP	Location of An	Size of An (mm)	Treatment modality	Postoperative resolution	Interval between treatment and CR
1	72F	0	14	CP	IC-Pcom	5.0	Clipping	CR	5 months
2	58M	0	20	CP	IC-Pcom	7.0	Clipping	PR	N/A
3	41F	1	9	CP	IC-Pcom	6.0	Clipping	CR	3 months
4	51F	0	10	CP	IC-Pcom	5.1	Clipping	CR	1 month
5	75F	0	1	IP	IC-Pcom	7.0	Clipping	CR	2 months
6	82F	0	6	CP	IC-Pcom	5.0	Coiling	CR	2 months
7	73F	0	12	IP	IC-Pcom	7.0	Clipping	CR	1 month
8	67F	0	7	CP	IC-Pcom	8.0	Coiling	CR	20 days
9	54F	0	3	CP	IC-Ach	10.0	Clipping	CR	1 month
10	69F	0	1	CP	IC-Pcom	6.2	Coiling*	PR	N/A
11	47F	0	1	IP	IC-Pcom	3.4	Coiling	CR	2 months
12	75F	0	7	CP	IC-Pcom	3.2	Coiling	CR	6 months
13	74F	0	1	CP	IC-Pcom	8.0	Coiling*	PR	N/A
14	58F	2	3	CP	IC-Pcom	5.0	Coiling	CR	4 months
15	84F	1	2	CP	IC-Pcom	3.5	Coiling	PR	N/A
16	70F	0	45	IP	IC-Pcom	3.6	Clipping	CR	10 days
17	52F	0	50	CP	IC-Pcom	4.0	Clipping	PR	N/A

\*Required double catheter technique. An: aneurysm, CP: complete palsy, CR: complete resolution, H&K: Hunt and Kosnik. IC-Ach: internal carotid-anterior choroidal, IC-Pcom: internal carotid-posterior communicating, IP: incomplete palsy, N/A: not applicable, ONP: oculomotor nerve palsy, PR: partial resolution.

## Results

### I. Characteristics of patients and aneurysms

The characteristics of the patients and the aneurysms in each group are shown in Table 2. The choice of treatment strategy was decided as with any other cerebral aneurysms, with attention to the individual aspects of risks and benefits of both procedures. The presence of ONP did not affect the choice of treatment procedure. The patients included 8 women in the endovascular group (n = 8) and 8 women and 1 man in the surgical group (n = 9), with a mean age of 69.5 years (range 52–84 years) and 60.7 years (range 41–75 years), respectively. There were no patients with a past history of diabetes mellitus. Of the 17 aneurysms, 16 were ICA posterior communicating artery aneurysms. One ICA anterior choroidal artery aneurysm was included in the microsurgical clipping group. All the cerebral aneurysms were confirmed by digital subtraction angiography. Magnetic resonance imaging in the sequence of constructive interference in steady state (CISS) was obtained in 9 of the 17 cases preoperatively. Those images revealed contact of the aneurysm with the oculomotor nerve; however, no

remarkable deviation of the nerve tract was observed, and it was not possible to estimate the extent of the aneurysmal compression to the nerve.

Subarachnoid hemorrhage (SAH) was observed in 2 of the 8 patients (25.0%) in the endovascular group and in 1 of the 9 patients (11.1%) in the microsurgical group. The Hunt and Kosnik grades of the patients with ruptured aneurysms were grade 1 in 2 patients (1 in the endovascular group and 1 in the surgical group) and grade 2 in 1 patient (endovascular group). The mean diameter of the aneurysms was 5.3 mm (range 3.2–8.0 mm) in the endovascular group and 6.1 mm (range 3.6–10.0 mm) in the microsurgical group. Significant difference was observed only in the intervals between the onset of ONP and treatment of aneurysm, with longer intervals in the microsurgical clipping group; 3.5 days (range 1–7 days) in the endovascular group and 18.2 days (range 1–50 days) in the surgical group. ONP was complete in 13 of the 17 patients (76.5%), including 7 of the 8 patients (87.5%) in the endovascular group and in 6 of the 9 patients (66.7%) in the microsurgical group. Other patients had incomplete ONP. Ptosis was observed in all patients, but pupillary reactions were prompt in

**Table 2 Characteristics of patients and aneurysms in each treatment group**

Characteristics	Endovascular coiling Patients, n = 8	Microsurgical clipping Patients, n = 9	<i>p</i> value
Sex			1.000
M	0 (0)	1 (11.1)	
F	8 (100)	8 (98.9)	
Age (yr)	69.5 ± 12.3	60.7 ± 12.1	0.158
Aneurysm location			1.000
IC-PCom	8 (100)	8 (98.9)	
IC-Ach	0 (0)	1 (11.1)	
Rupture of aneurysm			0.576
Unruptured	6 (75.0)	8 (98.9)	
Ruptured	2 (25.0)	1 (11.1)	
Size of aneurysm (mm)	5.3 ± 2.0	6.1 ± 2.0	0.433
Interval between onset and treatment (day)	3.5 ± 2.7	18.2 ± 17.6	0.034*
Degree of ONP			0.576
Complete	7 (87.5)	6 (66.7)	
Incomplete	1 (12.5)	3 (33.3)	

\*Significant at  $p < 0.05$ ,  $p$  values are Fisher's exact test for categorical variables and Mann-Whitney  $U$  test for continuous variables, values are mean ± SD (%). IC-Ach: internal carotid-anterior choroidal, IC-Pcom: internal carotid-posterior communicating, ONP: oculomotor nerve palsy.

the 4 patients with incomplete ONP. Follow-up data were available in all 17 patients for periods ranging from 4 months to 104 months (mean 33 months).

## II. Treatment procedures

Microsurgical clipping or endovascular coiling was performed within 24 hours after admission, in all 17 patients.

In all 9 cases of the microsurgical clipping group, surgery was performed via the standard pterional approach under general anesthesia. The intracranial ICA and the neck of the aneurysm were exposed by microscopic dissection of the Sylvian fissure, and complete clipping was achieved in all cases. When the size of the aneurysm was large, the aneurysms were punctured after clipping, to confirm complete clipping and to reduce aneurysmal mass. Aneurysmal adhesion to the oculomotor nerve was not always dissected to avoid nerve injury by the surgical procedures.

Endovascular coiling was performed under general anesthesia in all 8 cases. Microcatheter was inserted into the aneurysm via the femoral artery, and embolization was performed with detachable coils. Adjunctive techniques using double catheter method

were necessary in two aneurysms with a broad neck and complicated structure of the aneurysm. Assistance with a balloon or stent was not necessary in any cases in the present series. The mean volume embolization rate (VER) was 41.4% (range 28.4–56.7%), and complete obliteration was achieved in all 9 cases, and recanalization of the aneurysms was not observed during the follow-up period.

There were no remarkable complications caused by the procedures in both groups. All patients, including the 3 SAH patients, were discharged without any neurological deficits but ONP, and they returned to their daily lives.

## III. Recovery of ONP

Improvement of oculomotor nerve function was observed in all 17 patients after both procedures. In the endovascular coiling group, CR was obtained in 5 of the 8 patients (62.5%) and PR was obtained in 3 patients (37.5%). In the surgical clipping group, CR of ONP was obtained in 7 of the 9 patients (77.8%) and PR was obtained in 2 patients (22.2%) (Table 3). There was no significant difference in the outcome of ONP between the two groups.

All the patients with preoperative incomplete ONP obtained CR within 2 months regardless of

**Table 3 Clinical outcomes of oculomotor nerve palsy by each treatment**

	Number of patients (%)		Total
	Complete resolution	Partial resolution	
Endovascular coiling	5 (62.5)	3 (37.5)	8
Microsurgical clipping	7 (77.8)	2 (22.2)	9

$p = 0.620$ , statistical analysis by Fisher's exact test.

treatment modality. In the patients with complete ONP, CR was obtained in 4 of the 7 patients (57.1%) in endovascular coiling group and in 4 of the 6 patients (66.7%) in microsurgical clipping group (Table 1). Significant difference was not observed ( $p = 1.000$ ).

CR was obtained in the period ranging between 10 days and 6 months after treatment (Table 1). Recovery of the ONP was observed earlier in the microsurgical group than in the endovascular coiling group, but no significant difference was observed. Anisocoria, slight ptosis, and limitation of upward and/or downward gaze remained in the 5 patients with partial ONP resolution in various degrees, but these symptoms did not seriously disturb the patients' daily lives.

#### IV. Prognostic factors for functional recovery

All 4 patients who had incomplete ONP (pupillary sparing) obtained CR postoperatively, but significant difference was not observed because of the small number of cases. However, this result might suggest that incomplete ONP is a prognostic factor for good functional recovery. Other factors, including patients' age, presence of SAH, and interval between the onset of ONP and treatment, did not significantly affect the functional outcome of ONP (Table 4). Prognostic factors were assessed separately in endovascular group and microsurgical clipping group, but factors with significant difference were not revealed including VER in endovascular coiling group.

### Discussion

It is well known that ICA aneurysms can cause ONP, and it can be resolved by treatment of the aneurysms.<sup>6,7</sup> In the date when surgical clipping was the only treatment method for preventing aneurysmal bleeding, ONP and its resolution were thought to be caused by the compression and decompression of the aneurysm mass. The importance of the reduction of mass effect to the oculomotor nerve was emphasized.<sup>8</sup> From the late

**Table 4 Prognostic factor of functional outcome of oculomotor nerve palsy**

	Complete resolution Patients, n = 12	Partial resolution Patients, n = 5	$p$ value
Age (yr)	63.8 ± 13.1	67.4 ± 12.7	0.605
Size of aneurysm (mm)	5.7 ± 2.1	5.7 ± 1.9	0.990
Interval between the onset and treatment (day)	9.8 ± 11.8	14.8 ± 21.3	
Rupture of aneurysm			0.191
Unruptured	11 (91.7)	3 (60.0)	
Ruptured	1 (8.3)	2 (40.0)	
Degree of ONP			0.208
Complete	8 (66.7)	5 (100)	
Incomplete	4 (33.3)	0 (0)	

ONP: oculomotor nerve palsy. Values are mean ± standard deviation (%),  $p$  values are Fisher's exact test for categorical variables and Mann-Whitney  $U$  test for continuous variables.

1990s, several authors reported that endovascular treatment for these lesions could achieve satisfactory recovery of ONP, similar to microsurgical clipping.<sup>4,5</sup> As the endovascular coiling does not reduce the aneurysmal mass itself, the possible mechanism of aneurysm-induced ONP is explained by pulsation stress to the oculomotor nerve, not by the mere compression of the nerve.<sup>4</sup>

It is still controversial whether microsurgical clipping or endovascular coiling is better for the treatment of aneurysms causing ONP. There are a few clinical studies comparing the efficacy of both treatments (Table 5).<sup>2,3,9-12</sup> Chen et al.,<sup>2</sup> Güresir et al.,<sup>3</sup> and Khan et al.<sup>11</sup> reported better functional outcomes in the microsurgical clipping group and insisted that microsurgery should be the first-choice treatment for aneurysms with ONP. On the other hand, Ahn et al.,<sup>9</sup> Nam et al.,<sup>10</sup> and Brigui et al.<sup>12</sup> reported that there were no significant differences in the outcome of ONP recovery between the two treatments, as in our present study. Brigui et al.<sup>12</sup> reported 3 cases of recurrent ONP after coil embolization that needed secondary treatment (clipping in 2 patients and embolization in 1 patient) due to refilling of the aneurysms; however, these are the common complication of endovascular coiling itself, not a disadvantageous factor about ONP recovery.

Previous comparative studies demonstrate the mechanism of aneurysm-induced ONP according to the combination of compressive mass effect and pulsation stress. However, the mass effect of the aneurysm to the nerve is not clearly visualized in any previous reports including our present study.

**Table 5 Summary of the comparative studies between endovascular embolization and microsurgical clipping**

Authors	Year	Number of cases	Results	Prognostic factors
Ahn et al. <sup>9)</sup>	2006	17	No significant difference	Age in both groups DM, degree of preoperative ONP, and delayed intervention in coiling
Chen et al. <sup>2)</sup>	2006	13	Clipping is better	Treatment modality and degree of preoperative ONP
Nam et al. <sup>10)</sup>	2010	19	No significant difference Coiling may be better	None
Güresir et al. <sup>3)</sup>	2011	15	Clipping is better	Treatment modality
Khan et al. <sup>11)</sup>	2013	17	Clipping is better	Treatment modality and degree of preoperative ONP
Brigui et al. <sup>12)</sup>	2014	21	No significant difference Required secondary procedures after coiling in 3 cases	None
Current study	2014	17	No significant difference	None

DM: diabetes mellitus, ONP: oculomotor nerve palsy.

Microsurgical clipping can achieve complete and immediate elimination of pulsation stress to the nerve by the direct collapse of the aneurysm and/or detachment of the adhesion, possibly being the reason for a better or earlier functional recovery than in the endovascular coiling. The mechanism can be explained only by pulsation stress, and better outcomes in the microsurgery reported in the several studies<sup>2,3,11)</sup> do not clearly demonstrate the necessity of reduction of the aneurysmal mass effect. In endovascular coiling, reduction of the pulsation stress is thought to depend on the procedures in each institution, and factors including the VER, remnant of the aneurysm, and intervals between the embolization and formation of the thrombus around the coil may affect the functional outcome. We suppose that these factors can explain the different reported results in the ONP recovery after endovascular procedures. In our present study, the recovery of oculomotor nerve function tended to begin sooner after microsurgical clipping. If the follow-up period is shorter, the functional recovery may appear better in the microsurgical group than in the endovascular group. Longer follow-up may be necessary in patients treated with endovascular coiling.<sup>13)</sup>

As for prognostic factors, preoperative incomplete ONP seemed to be the only possible prognostic factor for good functional recovery in the present study. This result is similar to the reports by Ahn et al.,<sup>9)</sup> Chen et al.,<sup>2)</sup> and Khan et al.<sup>11)</sup> Pupillary sparing is a relatively uncommon symptom in aneurysm-induced ONP, but this suggests preservation of the microvascular supply and function of the pupillary fibers in the peripheral region of the oculomotor nerve, probably leading to a good recovery. Delayed

intervention in coiling was a prognostic factor of poor outcome in the comparative study by Ahn et al.<sup>9)</sup> Intervals between the onset of ONP and treatment of aneurysms were significantly longer in microsurgical clipping group in our present study. It is not deniable that this became a factor for the absence of significant difference in the outcome of ONP in each group.

The present rate of CR of ONP (77.8% after clipping and 62.5% after coiling) is not worse than in previous studies, but there were large differences in the clinical results among the previous clinical studies. The rate of CR has been reported to be between 30% and 86% after surgical clipping and between 0% and 100% after endovascular coiling.<sup>4,7,12-14)</sup> This difference is supposed to be caused by biases in the procedures and/or evaluation methods for oculomotor function recovery in each institution. The limitation of this study includes the small number of the patients and retrospective analysis of the clinical records. Therefore, large prospective comparative studies seem necessary to determine which procedure is better in the future.

In the present study, the outcome was satisfactory in both groups, indicating that both procedures are beneficial for achieving functional recovery of ONP. The treatment strategy for these lesions can be determined by considering the general risks of both procedures as with any other cerebral aneurysms, and the presence of ONP is not a disadvantageous factor for either procedure.

## Conclusion

The outcome of ONP with endovascular coiling and with microsurgical clipping was assessed.

There were no significant differences between the treatment procedures. Both procedures are beneficial for achieving functional recovery of ONP.

### Conflicts of Interest Disclosure

The authors have no conflicts of interest to report.

### References

- 1) Yanaka K, Matsumaru Y, Mashiko R, Hyodo A, Sugimoto K, Nose T: Small unruptured cerebral aneurysms presenting with oculomotor nerve palsy. *Neurosurgery* 52: 553–557; discussion 556–557, 2003
- 2) Chen PR, Amin-Hanjani S, Albuquerque FC, McDougall C, Zabramski JM, Spetzler RF: Outcome of oculomotor nerve palsy from posterior communicating artery aneurysms: comparison of clipping and coiling. *Neurosurgery* 58: 1040–1046; discussion 1040–1046, 2006
- 3) Güresir E, Schuss P, Setzer M, Platz J, Seifert V, Vatter H: Posterior communicating artery aneurysm-related oculomotor nerve palsy: influence of surgical and endovascular treatment on recovery: single-center series and systematic review. *Neurosurgery* 68: 1527–1533; discussion 1533–1534, 2011
- 4) Birchall D, Khangure MS, McAuliffe W: Resolution of third nerve paresis after endovascular management of aneurysms of the posterior communicating artery. *AJNR Am J Neuroradiol* 20: 411–413, 1999
- 5) Chalouhi N, Theofanis T, Jabbour P, Dumont AS, Gonzalez LF, Starke RM, Gordon D, Rosenwasser R, Tjoumakaris S: Endovascular treatment of posterior communicating artery aneurysms with oculomotor nerve palsy: clinical outcomes and predictors of nerve recovery. *AJNR Am J Neuroradiol* 34: 828–832, 2013
- 6) Feely M, Kapoor S: Third nerve palsy due to posterior communicating artery aneurysm: the importance of early surgery. *J Neurol Neurosurg Psychiatr* 50: 1051–1052, 1987
- 7) Giombini S, Ferraresi S, Pluchino F: Reversal of oculomotor disorders after intracranial aneurysm surgery. *Acta Neurochir (Wien)* 112: 19–24, 1991
- 8) Perneczky A, Czech T: Prognosis of oculomotor palsy following subarachnoid hemorrhage due to aneurysms of the posterior communicating artery. *Zentralbl Neurochir* 45: 189–195, 1984
- 9) Ahn JY, Han IB, Yoon PH, Kim SH, Kim NK, Kim S, Joo JY: Clipping vs coiling of posterior communicating artery aneurysms with third nerve palsy. *Neurology* 66: 121–123, 2006
- 10) Nam KH, Choi CH, Lee JI, Ko JG, Lee TH, Lee SW: Unruptured intracranial aneurysms with oculomotor nerve palsy: clinical outcome between surgical clipping and coil embolization. *J Korean Neurosurg Soc* 48: 109–114, 2010
- 11) Khan SA, Agrawal A, Hailey CE, Smith TP, Gokhale S, Alexander MJ, Britz GW, Zomorodi AR, McDonagh DL, James ML: Effect of surgical clipping versus endovascular coiling on recovery from oculomotor nerve palsy in patients with posterior communicating artery aneurysms: a retrospective comparative study and meta-analysis. *Asian J Neurosurg* 8: 117–124, 2013
- 12) Brigui M, Chauvet D, Clarençon F, Degos V, Sourour NA, Nouet A, Clémenceau S, Boch AL, Bernat AL, Di Maria F, Cornu P: Recovery from oculomotor nerve palsy due to posterior communicating artery aneurysms: results after clipping versus coiling in a single-center series. *Acta Neurochir (Wien)* 156: 879–884, 2014
- 13) Kassir SZ, Jouanneau E, Tahon FB, Salkine F, Perrin G, Turjman F: Recovery of third nerve palsy after endovascular treatment of posterior communicating artery aneurysms. *World Neurosurg* 73: 11–16; discussion e2, 2010
- 14) Stiebel-Kalish H, Maimon S, Amsalem J, Erlich R, Kalish Y, Rappaport HZ: Evolution of oculomotor nerve paresis after endovascular coiling of posterior communicating artery aneurysms: a neuro-ophthalmological perspective. *Neurosurgery* 53: 1268–1273; discussion 1273–1274, 2003

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