# Outcome of Oculomotor Nerve Palsy from Posterior Communicating Artery Aneurysms: Comparison of Clipping and Coiling

**Peng R. Chen, M.D.**
Department of Neurosurgery,
Thomas Jefferson University,
Philadelphia, Pennsylvania

**Sepideh Amin-Hanjani, M.D.**
Department of Neurosurgery,
University of Illinois at Chicago,
Chicago, Illinois

**Felipe C. Albuquerque, M.D.**
Division of Neurological Surgery,
Barrow Neurological Institute,
St. Joseph's Hospital
and Medical Center,
Phoenix, Arizona

**Cameron McDougall, M.D.**
Division of Neurological Surgery,
Barrow Neurological Institute,
St. Joseph's Hospital
and Medical Center,
Phoenix, Arizona

**Joseph M. Zabramski, M.D.**
Division of Neurological Surgery,
Barrow Neurological Institute,
St. Joseph's Hospital
and Medical Center,
Phoenix, Arizona

**Robert F. Spetzler, M.D.**
Division of Neurological Surgery,
Barrow Neurological Institute,
St. Joseph's Hospital
and Medical Center,
Phoenix, Arizona

**Reprint requests:**
Robert F. Spetzler, M.D.,
Neuroscience Publications,
Barrow Neurological Institute,
350 West Thomas Road,
Phoenix, AZ 85013.
Email: neuropub@chw.edu

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**OBJECTIVE:** Recovery of posterior communicating artery aneurysm-induced oculomotor nerve palsy (ONP) after aneurysm coiling has been reported. However, the coil mass may compromise recovery of the nerve. Therefore, we compared the outcome of coiling and clipping for this indication.

**METHODS:** We retrospectively compared the outcomes of ONP in 13 patients, six of whom underwent endovascular coiling and seven of whom underwent surgical clipping.

**RESULTS:** Six of the seven surgical patients with ONP recovered completely, compared with two of the six patients in the endovascular group. Of the patients with more than 1 year of follow-up, all six surgical patients recovered completely, compared with two of four endovascular patients ($P = 0.05$). In addition, preoperative complete or partial ONP also was associated with degree of resolution by survival analysis ($P = 0.03$). All patients with partial ONP in the surgical group and two of three patients in the endovascular group recovered without residual deficits, whereas three of the four patients with complete ONP in the clipping group and none in the coiling group recovered completely. Regardless of the treatment method, time to complete resolution of ONP was 6 months in both groups.

**CONCLUSION:** Clipping posterior communicating artery aneurysms was associated with a higher probability of complete recovery from ONP than coiling. Degree of preoperative ONP also affected recovery. If patients can tolerate surgery, it should be considered the treatment of choice.

**KEY WORDS:** Endovascular coiling, Oculomotor nerve palsy, Posterior communicating artery aneurysm, Surgical clipping

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Oculomotor nerve palsy (ONP) is a well-known clinical presentation associated with posterior communicating artery (PComA) aneurysms (5, 7, 8, 14, 21, 22, 26). Compression of the oculomotor nerve by the aneurysmal mass is considered to be the mechanism. In 1991, Guglielmi detachable coils were introduced as an alternative to surgical clipping for the treatment of intracranial aneurysms (9, 10). For PComA aneurysms associated with ONP, however, there has been concern about whether an aneurysm filled with a coil mass compromises recovery of nerve function. In comparison, does surgical clipping with decompression of the aneurysmal sac improve recovery of the oculomotor nerve?

In a few cases, ONP has been reported to resolve after Guglielmi detachable coiling (1, 13, 16). Stiebel-Kalish et al. (23) described 11 patients with PComA aneurysms who were treated with endovascular coiling. Contrary to previous reports, oculomotor nerve deficits remained after 1 year, even though the patients improved significantly. Yanaka et al. (25) treated 14 patients with aneurysmal ONP with microsurgical clipping and decompression of aneurysmal sac. During their 2 to 60 months of follow-up, oculomotor nerve function recovered completely in seven patients (43.8%) and partially in six (37%). The authors proposed that microsurgical clipping of a PComA aneurysm immediately relieved mass effect. However, the relative outcomes of endovascular coiling or surgical clipping of an aneurysm associated with ONP are still unclear. Therefore, we retrospectively compared the outcome of ONP in 13 comparable patients, six of whom underwent endovascular coiling and seven of whom underwent surgical clipping.

## PATIENTS AND METHODS

### Patients

Between 1999 and 2004, 93 cases of ruptured and unruptured PComA aneurysms were treated with surgical clipping at our institution. Between 2001 and 2004, 71 PComA aneurysms were treated with endovascular coil embolization. Seven patients from the surgical group and six patients from the endovascular group met the inclusion criteria and were comparable demographically (12 women, one man). The mean age of the endovascular patients was 57.3 ± 16 years (range, 45–85 yr), and the mean age of the surgical group was 53.8 ± 15.8 years (range, 27–78 yr). There were no significant demographic differences between the two groups ($P = 0.65$). Patient hospital medical records, operative reports, endovascular procedure reports, office follow-up records with a detailed ophthalmic examination, preoperative and postoperative angiographic studies and reports, and follow-up angiographic studies were reviewed retrospectively.

The inclusion criteria for this study were as follows: 1) a preoperative Hunt and Hess Grade III or better to enable an adequate neurological evaluation, 2) an angiographically confirmed PComA aneurysm associated with ipsilateral ONP, 3) more than 90% embolization or complete surgical obliteration of the aneurysm, and 4) available routine postoperative follow-up. Our institutional follow-up imaging protocols for coiled patients include cerebral angiography and magnetic resonance angiography at 6 and 12 months and cerebral angiography at 24 months. Clipped patients undergo cerebral angiography during surgery and at 3 and 10 years.

The one man among the 13 patients underwent surgical clipping. Five patients in the endovascular group and three in the surgical group had preoperative subarachnoid hemorrhage (SAH; range, Hunt and Hess Grade III). Among the endovascular group, four patients had ONP for 1 day before treatment, one had ONP for 4 days, and one had ONP for 28 days. In the surgical group, five patients had a 1-day history of ONP, one had a 10-day history, one had a 21-day history, and one had a 90-day history. All aneurysms but one were small (< 10 mm). SAH occurred in five endovascular patients and in four surgical patients ($P = 0.3$). There were no significant differences in severity of ONP, length of nerve palsy before treatment, or number of ruptured aneurysms between the two groups.

All endovascular procedures were performed by one of two interventionists (FCA or CM) with Matrix Detachable Coils (Boston Scientific, Inc., Natick, MA). Surgical clipping was performed by one of two senior cerebrovascular surgeons (JMZ or RFS).

### Criteria for ONP and Its Recovery

The criteria for complete preoperative ONP were as follows: 1) reports of diplopia, 2) ptosis, 3) ophthalmoplegia, and 4) papillary dysfunction. Partial preoperative ONP was identified as similar symptoms associated with partial extraocular movement in upward, medial, and downward gazes, or pupillary sparing.

The criteria for complete recovery of ONP were as follows: 1) patient did not report diplopia or photophobia in all direction of gazes; 2) complete resolution of ptosis; 3) full range of movement in medial, downward, and upward gaze; and 4) partial or complete recovery of pupillary reaction.

Time to ONP recovery was counted from the day of treatment to either the day of a normal extraocular movement examination obtained before hospital discharge or to the day of the first documented normal extraocular movement examination during the patient's follow-up examination.

### Follow-up

The endovascular patients all complied with the routine post-treatment follow-up at 1 to 3 months, 6 to 10 months, 12 months, 24 months, and annually thereafter. All patients who underwent aneurysmal clipping had a 1- to 3-month postoperative office visit. All but one had a 6- to 12-month office visit. All surgical patients underwent intraoperative cerebral angiography to confirm obliteration of their aneurysm and parent vessel patency. Based on our previous published risk of recurrence, these patients were also scheduled for cerebral angiography at 3 and 10 years (2). In both groups, patients with SAH underwent angiography on posthemorrhage Day 7 to evaluate for vasospasm. All patients have undergone serial follow-up ophthalmological examinations along with other neurological examinations. In the coiling group, the examinations were performed by PRC, FCA, and CM; in the clipping group, examinations were performed by PRC, RFS, and JMZ.

The total length of follow-up was 5 to 24 months (mean, 14 mo) in the endovascular group and 3 to 70 months (mean, 41 mo) in the surgical group. Patients in both groups had their first follow-up visit 1 to 3 months after treatment. Patients in the endovascular group underwent follow-up examinations 6 to 10 months and 24 months after treatment. All but one surgical patient was examined at 6 to 12 months and then at 36 months after treatment.

### Statistical Analysis

The baseline demographics, age, degree of ONP (complete or partial palsy), length of palsy before treatment, ruptured versus unruptured aneurysms, size of aneurysm, and sex in the two groups were compared statistically. Univariate analysis (i.e., $\chi^2$ test, $t$ test, and survival analysis) was used to compare the outcome of ONP in the two groups. Yanaka et al. (25) indicated that length of preoperative ONP of more than 5 days is significantly predictive of the poor outcome of ONP after treatment. Therefore, the presence of ONP for 5 days was arbitrarily chosen as the interval for univariate analysis. Multivariate and $\chi^2$ analysis were used to identify factors (e.g., age, length of ONP, degree of ONP, ruptured versus unruptured aneurysm) that might predict recovery of oculomotor function. Differences were considered significant at the level of $P = 0.05$ or less.

## RESULTS

The incidence of PComA aneurysms associated with ONP was 9%. The demographics and the resolution of ONP of 13 patients in two groups are detailed in *Table 1*. Overall, there were seven cases of complete and six cases of partial ONP; three patients with complete palsy were in the endovascular group and four were in the surgical group ($P = 0.8$).

Functional recovery of the ONP was usually noted first in the levator palpebrae muscle, followed by the medial rectus muscle, inferior rectus muscle, superior rectus muscle, constrictor muscles of the iris, and ciliary muscle. Patients with an incomplete recovery often presented with a residual inability to gaze upward and pupil constriction.

Overall, ONP resolved completely in eight patients (61%) and partially in five patients (39%). Of the seven surgical patients, ONP recovered completely in six (85%) and partially in one (15%). Only two (33%) of the endovascular patients recovered completely and four (67%) recovered partially. The difference between the two groups was significant ($P = 0.05$; *Table 2*). When patients with more than 1 year of follow-up were compared, six of six surgical patients recovered completely compared to two of four coiled patients ($P = 0.05$; *Table 3*).

Based on the survival analysis (Kaplan-Meier failure estimates), the time to complete resolution of ONP was 6 months in both groups. Clinically, ONP resolved completely within 6 months of treatment, regardless of the treatment method. No additional patients achieved complete resolution of ONP, although their function did continue to improve (*Fig. 1*).

The length of ONP before treatment had no significant effect on its complete resolution ($P = 0.3$), nor did age ($P = 0.6$) or the size of the aneurysm ($P = 0.4$). In contrast, the preoperative degree of ONP (i.e., complete or partial) was associated with a significant degree of resolution of ONP based on the survival analysis ($P = 0.03$). ONP recovered completely in five (83%) of six patients with partial ONP and in three (43%) of seven patients with complete ONP (*Fig. 2*). Three of three surgical patients with partial ONP and two endovascular patients recovered without residual oculomotor nerve deficits. In comparison, three of four surgical patients with complete ONP and none of the three endovascular patients attained complete recovery.

No endovascular patients or surgical patients showed aneurysmal regrowth or coil compaction on follow-up cerebral angiography or magnetic resonance angiography.

**TABLE 1. Demographics, type of oculomotor nerve palsy, type of treatment procedure, and recovery of oculomotor nerve palsy[a]**

| Patient type and no. | Age (yr)/sex | Length of palsy (d) | SAH | Size (mm) | Complete versus partial CNIII palsy | Type of oculomotor nerve palsy recovery |
|---|---|---|---|---|---|---|
| Coil 1 | 72/F | 1 | Y | 6 | Complete | Partial: The pupil is still larger than the contralateral one; diplopia in primary gaze and EOM of up, down, and medial gaze remain incomplete. |
| Coil 2 | 45/F | 4 | Y | 5 | Complete | Partial: no diplopia in primary gaze, but upgaze remains incomplete. |
| Coil 3 | 49/F | 1 | Y | 8 | Partial | Complete |
| Coil 4 | 85/F | 1 | Y | 5 | Complete | Partial: No diplopia in primary gaze, but upgaze remains incomplete. |
| Coil 5 | 45/F | 28 | N | 5 | Partial | Partial: slight ptosis, mild diplopia in primary gaze, upgaze remains incomplete. |
| Coil 6 | 48/F | 1 | Y | 7 | Partial | Complete: the pupil is reactive but slightly larger than the contralateral one. |
| Clip 1 | 27/M | 1 | Y | 17 | Complete | Complete |
| Clip 2 | 48/F | 1 | Y | 7 | Partial | Complete |
| Clip 3 | 61/F | 90 | N | 9 | Partial | Complete |
| Clip 4 | 49/F | 10 | N | 7 | Complete | Partial: the pupil is slightly larger than the contralateral one; no diplopia in primary gaze, but medial gaze remains incomplete. |
| Clip 5 | 62/F | 1 | Y | 5 | Complete | Complete |
| Clip 6 | 52/F | 21 | N | 8 | Complete | Complete |
| Clip 7 | 78/F | 1 | Y | 7 | Partial | Complete |

[a] SAH, subarachnoid hemorrhage; CN, cranial nerve; Y, yes; EOM, extraocular movement; N, no.

**TABLE 2. Oculomotor nerve palsy recovery by type of procedure**

| | Partial recovery oculomotor nerve palsy | Complete recovery oculomotor nerve palsy | Total (n = 13) |
|---|---|---|---|
| Clip | 1 | 6 | 7 |
| Coil | 4 | 2 | 6 |

**TABLE 3. Oculomotor nerve palsy recovery by type of procedure among patients with more than 1 year of follow-up**

| | Partial recovery oculomotor nerve palsy | Complete recovery oculomotor nerve palsy | Total (n = 10) |
|---|---|---|---|
| Clip | 0 | 6 | 6 |
| Coil | 2 | 2 | 4 |

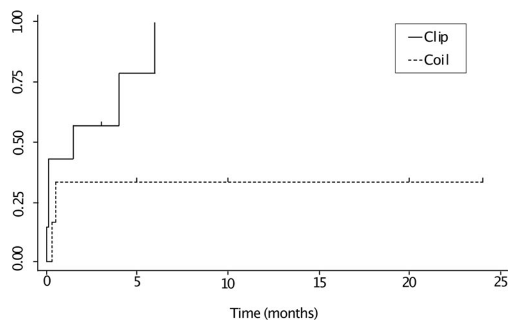


**FIGURE 1.** *Graph showing the time to complete resolution of ONP by procedure (Kaplan-Meier failure estimates).*

## DISCUSSION

Aneurysm-induced ONP may result from direct mechanical compression (12, 21). There are many reports on the outcome of oculomotor nerve function after direct aneurysmal clipping (4, 8, 15, 17, 18, 21, 25). Overall, the rate of complete resolution of ONP after clipping has ranged between 41 and 57% (17, 18, 25). When surgery has been performed during the first 3 to 5 days after the occurrence of ONP, the rate of full recovery has reportedly been as high as 80 to 90% (18, 25).

Since the 1990s, endovascular Guglielmi detachable coil embolization has become the primary alternative to microsurgical clipping for treating intracranial aneurysms. The perioperative risks are low and the procedure is well tolerated by elderly patients (19, 24). Nonetheless, coiling does not resolve all of the mass effect caused by an aneurysm. Furthermore, the coil mass itself could contribute to mass effect. However, there are reports that ONP has resolved after coil embolization of PComA aneurysms (1, 13, 16). In such cases, the recovery of oculomotor nerve function has been attributed to the elimination of aneurysmal pulsatility after coiling (1). Stiebel-Kalish et al. (23) published a prospective neuro-ophthalmological study of 11 patients with ONP from PComA aneurysms treated by endovascular coiling. Oculomotor nerve function was evaluated before treatment and 1 week, 3 months, and 12 months thereafter. The degree of residual ONP was classified as minimal residual ONP (trace upgaze deficit with mild diplopia only when looking up), moderate residual ONP (diplopia present with upgaze and downgaze but not primary gaze), or significant (residual diplopia with primary gaze, a slight adduction deficit, and a mild upgaze deficit). At the 1-year follow-up examination, ONP had failed to resolve completely in any of the 11 patients. Four patients had minimal residual ONP and six had moderate ONP. One patient reported significant residual diplopia. After comparing their results with those of Yanaka et al. (25), the authors concluded that oculomotor nerve dysfunction improves comparable with the recovery observed after surgical clipping despite the potential mass effect of coiling. However, the conclusion may have been stronger if these were demographically comparable groups of patients with similar follow-up.

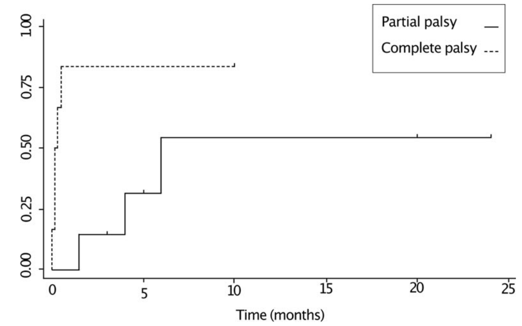


**FIGURE 2.** *Graph showing the time to resolution of ONP by degree of palsy regardless of procedure (Kaplan-Meier failure estimates).*

We directly compared resolution of ONP in two demographically comparable groups of patients after surgical or endovascular treatment. Follow-up was similar in both groups. Six (85%) of seven patients with ONP experienced complete resolution after clipping, compared with only two of six patients treated with coiling. The difference remained significant even when we compared only patients with more than 1 year of follow-up in both groups: six of six surgical patients recovered completely compared with two of four endovascular patients (*Table 2*). Although the sample is small, the difference in recovery suggests that surgical clipping improves the chances of oculomotor nerve recovery.

Survival analysis was used to determine the time to resolution of ONP. In both groups, all patients who recovered oculomotor nerve function after treatment did so completely within 6 months. Although the remaining patients continued to recover slowly beyond the 6 months, none reached the criteria of complete recovery of ONP. Giombini et al. (6), Hamer (11), and Leivo et al. (18) (based on 28 surgical cases) found that ONP improved within the first year of symptom onset and surgery; no changes were noted later. The argument that outcomes would be different in patients with longer follow-up can be discounted because all of our patients who recovered completely did so in fewer than 6 months.

The degree of ONP (i.e., complete or partial) affected recovery of nerve function regardless of treatment method. Three (43%) of seven patients from both groups with complete ONP before surgery recovered completely. In contrast, five (83%) of six patients with partial ONP recovered completely ($P = 0.03$; *Fig. 2*). This finding is consistent with previous studies that have stressed that degree of preoperative palsy is an important factor in determining the recovery of nerve function (4, 11, 17, 20). Partial ONP promises better recovery after either clipping or coiling of a PComA aneurysm. In this study, three of four patients with complete ONP in the surgical group and zero of three in the endovascular group recovered completely, whereas three of three surgical patients and two of three endovascular patients with partial palsy recovered nerve function without residual dysfunction. Although statistical analysis is precluded given the small number of patients, the findings suggest that complete ONP will resolve after a PComA aneurysm is clipped.

In the surgically treated group, there was no attempt to puncture or to open the aneurysm sac for decompression after its neck was clipped. After clipping, aneurysms typically shrink and thrombose without the need to puncture the sac. Previous experiences indicate that there is no difference in the recovery of oculomotor nerve function in patients whose aneurysmal sacs have been puncture-decompressed compared with those whose were not (17, 18).

Complete recovery from an ONP related to a PComA aneurysm has been indicated to be closely linked with the interval between onset of symptoms and clipping of the aneurysm (11, 17, 18, 20, 25). In our univariate analysis, the duration of ONP before treatment did not seem to correlate with the ultimate recovery of nerve function. The small size of our sample (because of the rarity of cases) raises the probability of a Type I error. However, previous reports suggesting a strong correlation between length of ONP and the chance of complete recovery did not analyze differences in outcome associated with partial and complete ONP (11, 17, 18, 20, 25). When degree of ONP (partial and complete) before surgical treatment of aneurysms was considered, the duration of ONP before treatment did not seem to have a significant effect on recovery. Partial palsy at the time of surgery was followed by an early and rapid recovery (3, 4). A nerve in partial palsy from compression is likely in a neurapraxic phase, which is reversible.

Age, size of aneurysm, and presence of SAH had no effect on recovery of ONP. Furthermore, there were no differences between the surgical and endovascular groups, consistent with other reports ($P = 0.6$). These reports also suggested that sex is irrelevant to the outcome of ONP (17, 18, 25). With only one male in our series, however, we were unable to address this issue.

## CONCLUSION

Surgical clipping of a PComA aneurysm causing ONP seems to be associated with a higher probability of complete recovery than endovascular treatment. Therefore, we recommend surgical clipping if the patient is able to tolerate the procedure. The presence of partial or complete ONP before treatment is another factor that affects the recovery of oculomotor nerve function, whereas age, size of aneurysm, length of palsy, and SAH do not seem to affect the resolution of ONP. We recognize the limitation of the small number of patients in this study because of the rarity of PComA aneurysm-induced ONP. A multicenter prospective study is needed to validate these findings.

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## COMMENTS

The authors have done an excellent job in retrospectively reviewing their experience with ocular nerve palsy recovery after treatment of posterior communicating artery aneurysms. They reviewed 13 patients, with 6 undergoing endovascular coiling and 7 undergoing surgical clipping. The authors correctly cite the distinct difference between complete and partial ocular nerve palsies and an improved potential for recovery after either treatment modality in patients with partial surgeries. In addition, this is an important finding in that patients with complete palsies have a better chance for recovery after surgical clipping. Clearly, a larger population base would be desirable; however, this study shows that in competent surgical and endovascular hands, surgical treatment appears to be superior. Moreover, the authors point out that surgical decompression of the aneurysm does not need to be pursued in order to achieve recovery in nerve function. This is an interesting review of one center's clinical experience, which facilitates our abilities as microsurgeons and endovascular surgeons to select the appropriate therapy for a given aneurysm type and presentation.

**Philip E. Stieg**
*New York, New York*

The authors have retrospectively evaluated 13 patients presenting with oculomotor nerve palsy (OMP) due to compression of the oculomotor nerve by a posterior communicating artery aneurysm. The purpose of the study was to determine if there was a difference in the recovery from OMP between patients treated by surgical clip ligation and those treated by endovascular coiling. Intuitively, one would expect surgical clip ligation to more rapidly eliminate the mass effect, as opposed to endovascular therapy, which replaces a sac of blood with a sac of platinum. In this small, retrospective study, the authors have provided evidence that the intuition is correct. Although the small size and retrospective nature of the study are detractors that could potentially have led to some treatment bias, the groups of patients were remarkably similar in demographics, presence of subarachnoid hemorrhage, and aneurysm size.

Interestingly, the authors also demonstrated that the length of time from onset of OMP to treatment, the age of the patient, and the aneurysm size did not correlate with likelihood of resolution, whereas the preoperative degree of OMP was significantly associated with likelihood of complete resolution.

It has been our bias to preferentially treat patients with aneurysmal compression of the oculomotor nerve by direct surgical clip ligation, and the present study would support that bias.

**Daniel L. Barrow**
*Atlanta, Georgia*

The report by Chen et al. describes the outcome of ocular nerve palsy in 13 patients who underwent endovascular management and surgical management. Their findings primarily relate to the degree of OMP. In those who had incomplete lesions, the majority of endovascularly treated patients had resolution. However, when presenting with complete ocular motor nerve palsy, none in the endovascular group recovered, and all in the surgical group had complete recovery.

This is a controversial topic, as there have been reports citing improvement in terms of visual pathway performance, particularly in regards to optic apparatus compression when treated with endosaccular approach. It makes intuitive sense that reduction of mass effect, in addition to removal of pulsations, would allow a nerve to recover more completely. Based on this report, I believe that expectations of nerve recovery based on modality of treatment are something that must be discussed with the patient and family prior to intervention.

Obviously, more reports on this topic and verification of their findings need to be reported by other centers.

**Robert H. Rosenwasser**
*Philadelphia, Pennsylvania*

Chen et al. discuss the outcomes for a small series of patients with ruptured and unruptured posterior communicating artery origin region aneurysms associated with third nerve palsy (ONP). Their data suggest that surgical clipping is superior to endovascular coil embolization from the standpoint of recovery of oculomotor nerve function. The exclusive use of bioactive Matrix Detachable Coils (Boston Scientific, Inc., Natick, MA) in the endovascular group represents a potential confounding factor, given that these coils are specifically designed to provoke cellular infiltration. It is conceivable that inflammatory effects associated with these coils (or other "bio-active coated coils") could potentially have an impact on recovery from cranial nerve paresis associated with aneurysms. In addition, although controversial, aneurysm treated with Matrix coils may have a higher recanalization rate than bare platinum metal coils (1), which may also impact nerve recovery.

In the endovascular group, five of six patients presented with subarachnoid hemorrhage, while only three of seven surgical patients did. The authors indicate that the presence of subarachnoid hemorrhage had no effect on recovery from ONP. However, given the overall small sample size, it is hard to believe that any meaningful statistical statements can be made with respect to population subsets. As subarachnoid hemorrhage may represent a completely different mechanism for nerve dysfunction than pure mass effect in the unruptured aneurysm state, I do not feel that subarachnoid hemorrhage can be discounted as a significant bias against the endovascular group.

Most importantly, both the report by Johnston et al. (3) on unruptured cerebral aneurysms and the International Subarachnoid Aneurysm Trial (ISAT) (2) indicated superior overall outcomes in patients after coil embolization in comparison to surgery. As such, while the current topic is certainly of interest and worthy of further investigation, it is critical not to lose sight of the data indicating better overall functional outcomes for patients after endovascular coil embolization.

**Peter A. Rasmussen**
*Cleveland, Ohio*

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2. ISAT Collaborative Group: International Subarachnoid Aneurysm Trial (ISAT) of neurosurgical clipping versus endovascular coiling in 2143 patients with ruptured intracranial aneurysms: A randomised trial. **Lancet** 360:1267–1274, 2002.
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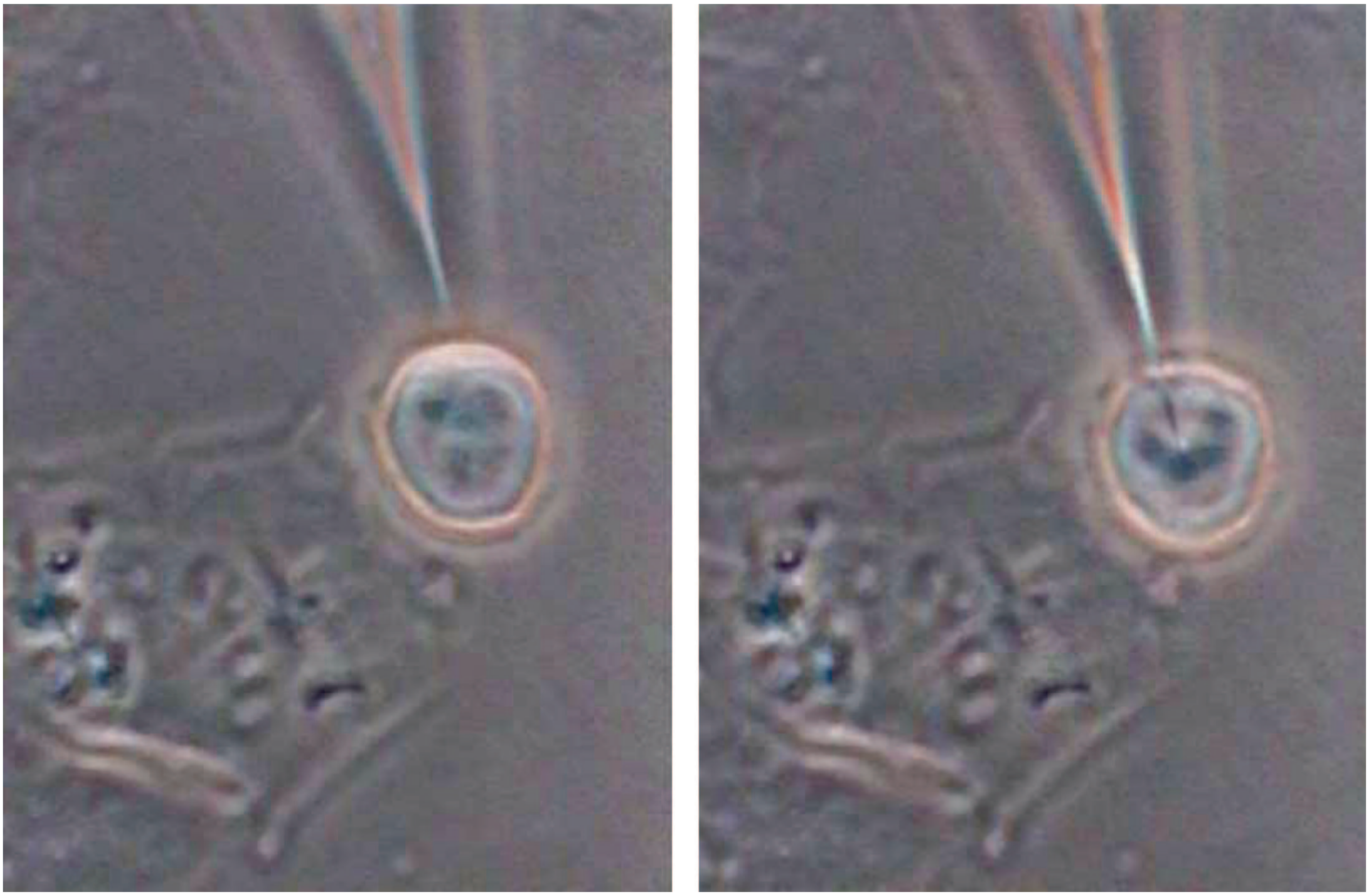

*Digital image of single-cell sensing. Left, and optical nanosensor before insertion into a single human mammary carcinoma cell. Right, optical nanosensor inserted into the cell. (T. Vo-Dinh, P.M. Kasili, M.B. Wabuyele. Nanoprobes and Nanobiosensors for Monitoring and Imaging Individuals Living Cells.* ***Nanomedicine.*** *2 (2006) 22–30.)*