

Efficacy and long-term results of endovascular embolization and surgical clipping for posterior communicating artery unruptured aneurysms complicated with oculomotor nerve palsy

Xun Shen, MD^{a,*}, Wenlei Wang, MD^a, Huaihai Qin, MD^a, Chun-Feng Ren, MD^b, Bu-Lang Gao, MD, PhD^c 

Abstract

This study aimed to investigate the efficacy and long-term outcomes of endovascular embolization and surgical clipping for patients with posterior communicating artery unruptured aneurysms (PcomAs) concomitant with oculomotor nerve palsy (ONP). No significant ($P > .05$) difference existed in the age, gender, proportion of complete ONP, and size of eye fissure and pupil before treatment between 2 groups. After compared with before treatment, the eye fissure was widened significantly ($P < .05$) and the pupil narrowed significantly ($P < .05$), but no significant ($P > .05$) differences existed between the 2 groups. Complete ONP recovery was observed in 32 (80%) patients in the embolization group and 31 (77.5%) in the microsurgical group, partial ONP recovery occurred in 6 (15%) in the embolization group and 8 (20%) in the microsurgical group. The recovery rate was 95% in the embolization group and 97.5% in the microsurgical group, with no significant ($P > .05$) difference between 2 groups. The recovery rate of the ONP was significantly ($P < .01$) greater in the microsurgical group than that in the embolization group at follow-up of 1 month, 3 months, six and 12 months, respectively. At 18 months, the ONP recovery rate was not significantly different between 2 groups (95% vs 97.5%). Surgical clipping may have a faster effect on the recovery of oculomotor nerve palsy than endovascular embolization for patients with posterior communicating artery unruptured aneurysms complicated with oculomotor nerve palsy, but both approaches may result in a similar effect on the nerve recovery in the long run.

Eighty patients treated with endovascular embolization or surgical clipping were retrospectively enrolled into the endovascular embolization group or surgical clipping and analyzed.

Abbreviations: IQR = interquartile range, ONP = oculomotor nerve palsy, Pcom = posterior communicating artery, PcomAs = posterior communicating artery unruptured aneurysms.

Keywords: endovascular embolization; surgical clipping; posterior communicating artery; intracranial aneurysms; oculomotor nerve palsy.

1. Introduction

Aneurysms of the posterior communicating artery (Pcom) are the second most common and represent approximately 25% of all cerebral aneurysms and 50% of aneurysms of the internal carotid artery.^[1,2] Unilateral oculomotor nerve palsy (ONP) may present in 20–25% of patients with ruptured or unruptured Pcom aneurysms.^[1–6] In patients with ruptured Pcom aneurysms,

the oculomotor nerve is directly injured by aneurysm bleeding or localized hematoma and irritation from subarachnoid hemorrhage. In patients with unruptured Pcom aneurysms complicated with ONP, aneurysm sac compression, arterial pulsation, and nerve edema caused by venous obstruction may cause ONP.^[3,5,7] In patients with Pcom aneurysms complicated with ONP, treatment of the aneurysm promotes recovery of ONP. Surgical clipping of the aneurysm may relieve immediately the mass effect,

Funding information: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Consent for publication: All data have been approved for publication.

Informed consent: Informed consent has been obtained from the patient for publication of the data in this study.

The authors have no funding and conflicts of interest to disclose.

The authors declared that they have no conflict of interest.

The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

Availability of data and material: The data are available from the corresponding author on reasonable requirement.

Ethics approval and consent to participate: This study was approved by the ethics committee of our hospital, and all patients had signed the informed consent to participate.

^a Department of Neurosurgery, Emergency General Hospital, Beijing, China,

^b Department of Laboratory Analysis, Zhengzhou University First Affiliated

Hospital, Zhengzhou, China, ^c Shijiazhuang People's Hospital, Shijiazhuang, China.

*Correspondence: Xun Shen, Department of Neurosurgery, Emergency General Hospital, 29 Henanli, Xibai, Beijing, China, 100028 (e-mail: shenxun2006@163.com).

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How to cite this article: Shen X, Wang W, Qin H, Ren C-F, Gao B-L. Efficacy and long-term results of endovascular embolization and surgical clipping for posterior communicating artery unruptured aneurysms complicated with oculomotor nerve palsy. *Medicine* 2022;101:34(e30421).

Received: 1 April 2022 / Received in final form: 25 July 2022 / Accepted: 27 July 2022

<http://dx.doi.org/10.1097/MD.00000000000030421>

and endovascular embolization may promote ONP recovery by eliminating aneurysm shrinkage and aneurysm or arterial pulsation.^[4,5,8,9] Currently, no best approaches have been agreed on for the treatment of ONP concomitant with Pcom aneurysms, and delayed ONP improvement beyond the time of 1 year has not been carefully recorded. It was hypothesized that surgical clipping of the Pcom aneurysm had good effect on improving ONP in patients with Pcom aneurysms complicated with ONP. This study was consequently performed to investigate the effect of surgical clipping and endovascular embolization on the improvement of ONP, especially at 1 year beyond the treatment.

2. Materials and Methods

This retrospective study was performed between March 2010 and March 2019 in our hospital, and the ethics committee of our hospital approved the study, with the informed consent being signed by all patients to participate. The inclusion criteria were consecutive patients (without age limit) with imaging-confirmed unruptured Pcom aneurysms complicated with ONP which were treated with endovascular embolization or surgical clipping. The exclusion criteria were patients with contraindications to endovascular embolization or surgical clipping and other neurological complications which affected the procedures. The features, benefits, difficulties, cost and risks of endovascular and surgical treatment as well as aneurysm characteristics were assessed by endovascular radiologists and neurosurgeons, and the patients chose the relevant treatment modalities after informed consent.

The endovascular embolization procedure was performed under general anesthesia, and the right femoral artery was punctured for insertion of an arterial sheath. A 6F guiding catheter was navigated to the petrous segment of the internal carotid artery, and under roadmap guidance, a microcatheter was sent along a micro-guidewire to the aneurysm sac for embolization with appropriate coils until dense packing. For wide-necked aneurysms, the stent-assisted coiling or double-microcatheter technique was used to pack the aneurysm. After embolization, angiography was performed to check if the aneurysm was completely embolized.

For surgical clipping, the patient was in the supine position, and the procedure was conducted under general anesthesia. After the head was frame-fixed, the standard pterional approach was used with the head turning to the contralateral side for 30°–40°. After the parent artery and the aneurysm were exposed, an appropriate clip was selected to clip the aneurysm neck. No other measures were performed for nerve decompression.

Clinical follow-up was conducted at, 1, 3, 6, 12, and 18 months after the procedure. Computed tomography angiography was conducted for patients treated with surgical clipping 2 weeks after surgery, and digital subtraction angiography for patients with endovascular embolization was performed 6–12 months after embolization. All patients were evaluated for changes in the eye fissure and pupils before and after the treatment, recovery of the ONP, and time of the ONP recovery after the procedure. The pretreatment and posttreatment ONP was evaluated by a neuro-ophthalmological physician who was blinded to the clinical data. ONP was assessed based on 4 criteria: ptosis, fixed mydriasis, diplopia, and ophthalmoplegia.^[8,10,11] The ONP was partial with only one or more of these symptoms or signs but complete if all 4 were present. After treatment, complete recovery of ONP was defined as disappearance of all these symptoms or signs. If one or more remained, partial recovery was diagnosed. Complete recovery of ONP was defined as the primary outcome at evaluation.

2.1. Statistical analysis

The statistical analysis was performed with the SPSS 20.0 software (IBM, Chicago, IL). Measurement data were presented as

mean \pm standard deviation and tested with the Student *t* test if in normal distribution or median and interquartile range and tested with the Mann–Whitney *U* test if in skew distribution. Enumeration data were presented in numbers and percentages and tested with the Chi-square test. The significant *P* value was set at < 0.05 .

3. Results

Eighty patients met the inclusion criteria and were enrolled into 2 groups: endovascular embolization group and microsurgical clipping group, with 40 patients in each group (Table 1). In the embolization group, there were 23 (57.5%) males and 17 (42.5%) females with an age range of 32–74 (mean 52.16 ± 3.54) years, complete ONP in 25 (62.5%) patients and partial ONP in 15 (37.5%) (Table 1). In the microsurgical group, there were 22 (55%) male and 18 (45%) female patients, with an age range of 33–74 (mean 53.45 ± 3.29), complete ONP in 26 (65%) and partial ONP in 14 (35%). No significant differences ($P > .05$) existed in the age, gender, and proportion of complete ONP between the 2 groups. The eye fissure (2.50 ± 0.15 mm for the embolization group and 2.43 ± 0.25 mm for the microsurgical group) and pupils (4.56 ± 0.25 mm for the embolization group and 4.58 ± 0.16 for the microsurgical group) were not significantly ($P > .05$) different between 2 groups before treatment.

Endovascular embolization and surgical clipping were both successfully performed in all patients (Table 1). Complications occurred in both groups after treatment, including 2 cases of cerebral vasospasm, 1 case of slight hemiparesis, and 1 case of hydrocephalus in the embolization group. In the microsurgical clipping group, 3 cases of cerebral vasospasm, 2 cases of slight hemiparesis, and 2 cases of hydrocephalus occurred as periprocedural complications. No significant ($P > .05$) difference existed in the complications between the 2 groups.

One week after treatment, the eye fissure (6.15 ± 0.24 mm for the embolization group and 6.09 ± 0.17 mm for the microsurgical group) was significantly ($P < .01$) widened while the pupil (3.85 ± 0.41 mm for the embolization group and 3.90 ± 0.16 mm for the microsurgical group) was significantly ($P < .05$) narrowed compared with those before treatment. However, the eye fissure and pupil were not significantly ($P > .05$) different after treatment between 2 groups.

At follow-up after the treatment, the ONP was recovered in 6 (15%) patients at 1 month, 11 (27.5%) at 3 months, 16 (40%) at 6 months, 21 (52.5%) at 12 months, and 38 (95.0%) at 18 months in the embolization group, whereas those numbers for the microsurgical group were 20 (50%), 26 (65%), 30 (75%), 32 (80%), and 39 (97.50%), respectively (Table 2 and Fig. 1). The recovery rate of ONP was significantly ($P < .01$) greater in the microsurgical group than that in the embolization group at the follow-up time of 1 month, 3, 6 and 12 months.

At the last follow-up 18 months after treatment, all patients were followed up. Complete ONP was observed in 32 (80%) patients in the embolization group and 31 (77.5%) in the microsurgical group, partial ONP recovery occurred in 6 (15%) in the embolization group and 8 (20%) in the microsurgical group. Two (5%) patients in the embolization group and 1 (2.5%) patient in the microsurgical group had no recovery of ONP. The recovery rate was 95% in the embolization group and 97.5% in the microsurgical group, with no significant ($P > .05$) difference between the 2 groups (Table 2 and Fig. 1).

4. Discussion

In this study investigating the efficacy and long-term outcomes of endovascular embolization and surgical clipping for patients with posterior communicating artery aneurysms (PcomAs) concomitant with ONP, it was found that the eye fissure and pupils were significantly improved after the treatment in the same

Table 1
Demography and treatment outcomes.

Variables		Embolization group	Microsurgical group	P
M/F		23/17	22/18	0.58
Age (y, range, mean)		32–74 (52.16 ± 3.54)	33–74 (53.45 ± 3.29)	0.87
Aneurysm diameter (mm)		7.8 ± 1.2	8.1 ± 1.4	0.76
Complete ONP		25 (62.5%)	26 (65%)	0.88
Partial ONP		15 (37.5%)	14 (35%)	0.89
Hypertension (n,%)		11 (27.5%)	15 (37.5%)	0.67
Dyslipidemia (n,%)		6 (15%)	9 (22.5%)	0.45
Duration of ONP (d, median and IQR)		8 (8–19)	12 (6–18)	0.87
Treatment success rate		100%	100%	–
Eye fissure (mm)	Pretreatment	2.50 ± 0.15	2.43 ± 0.25	0.13
	Posttreatment	6.15 ± 0.24 [†]	6.09 ± 0.17 [†]	0.20
Pupil (mm)	Pretreatment	4.56 ± 0.25	4.58 ± 0.16	0.67
	Posttreatment	3.85 ± 0.41 [†]	3.90 ± 0.14 [†]	0.47
Follow-up 18 months later (n,%)	Complete recovery	32 (80.00)	31 (77.50)	0.79
	Partial recovery	6 (15.00)	8 (20.00)	0.56
	No recovery	2 (5.00)	1 (2.50)	0.56
	Recovery rate	95.0%	97.5%	0.56

IQR = interquartile range; ONP = oculomotor nerve palsy.
^{*}P < .01.
[†]P < .05 compared with pretreatment data.

Table 2
Time of oculomotor nerve palsy recovery (n, %).

Group	No.	One month	3 months	6 months	12 months	18 months
Embolization	40	6 (15.00)	11 (27.50)	16 (40.00)	21 (52.50)	38 (95.00)
microsurgical	40	20 (50.00)	26 (65.00)	30 (75.00)	32 (80.00)	39 (97.50)
P	–	0.001	0.001	0.002	0.009	0.561

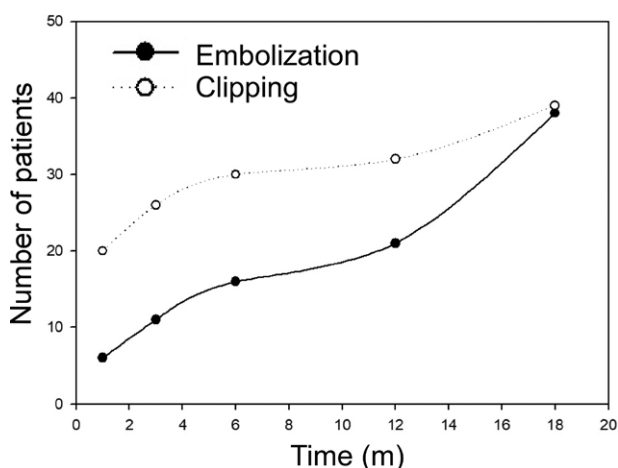


Figure 1. Trends of recovery of oculomotor nerve palsy with time for patients treated with embolization or surgical clipping.

group even though no significant difference existed between the 2 groups. Endovascular embolization and surgical clipping both have significant effects on the recovery of ONP concomitant with posterior communicating artery aneurysms, and the time of recovery is significantly shorter for surgical clipping than that for endovascular embolization even though the recovery rate was not significantly ($P > .05$) different at 18-month follow-up between the 2 groups.

ONP is a common symptom of Pcom aneurysms, and the optimal approach of treatment is controversial. A common opinion is that the surgical clipping is better than the endovascular embolization in the recovery of ONP even though both modalities are beneficial.^[2,12,13] Surgical clipping may entail relatively greater injuries to the patient as compared with the endovascular embolization, but can effectively stop the spread of arterial pulsation, block aneurysm compression on the oculomotor nerve, and prevent aneurysm rupture, promoting recovery of ONP.^[14] After endovascular embolization, the aneurysm dome is filled with coils, thrombosis occurs within the aneurysm sac, and shrinkage of the aneurysm dome also takes place later, which may all decrease the spread of pulsation from the aneurysm dome and parent artery, thus decreasing the pulsation effect on the oculomotor nerve.^[8,12,13,15] However, the compression effect of the coiled aneurysm dome may remain for a longer time than that in surgical clipping, which accounts for the slower recovery of ONP as demonstrated in our study.

Surgical clipping and endovascular treatment may have a similar effect on the recovery of ONP. In a meta-analysis on 414 patients with ONP caused by Pcom aneurysms, a subgroup analysis of ONP recovery in 115 patients with unruptured aneurysms showed a similar effect of endovascular and surgical treatment although the pooled outcomes indicated higher full recovery rate of ONP in the surgical clipping group than that in the endovascular embolization group.^[16] In a study with 102 patients, a multivariate analysis of the whole cohort also revealed a similar effect on the ONP recovery between endovascular embolization and surgical clipping.^[6] Signorelli et al have also compared the effect of endovascular and surgical treatment on ONP improvement in 55 patients with unruptured Pcom aneurysms, and it was found that no significant difference was revealed between embolization and surgical clipping on the recovery of ONP, with the best predictors for ONP recovery as timely, complete and durable aneurysm occlusion.^[5] However, other studies have demonstrated that surgical clipping may have better effects on ONP improvement than endovascular embolization.^[2,12,13] Tan et al compared the effect of endovascular treatment and surgical clipping on the recovery of ONP in 176 patients with Pcom aneurysms complicated with ONP,

and they found that surgical clipping had a quicker recovery (83.87 ± 34.70 days vs 137.45 ± 44.94 days) and a higher rate of recovery (98.5% vs 68.2%) than those of endovascular embolization.^[2] Liu et al^[13] compared the effect of surgical clipping in 112 patients and endovascular embolization in 40 patients with Pcom aneurysms complicated with ONP. In this study, the time to complete or partial ONP recovery was significantly ($P < .001$) shorter for surgical clipping than for endovascular embolization (86.7 ± 35.7 days vs 132.6 ± 37.5 days) while postoperative ONP recovery was significantly superior in the surgical clipping group than that in the embolization group (HR 2.625 vs 0.572). In a systematic review and meta-analysis comparing clipping versus endovascular coiling for the management of 384 patients with PcomAs complicated with the third nerve palsy,^[14] the overall complete ONP recovery rate was 42.5% in the coiling group with 127 patients compared with 83.6% in the clipping group with 257 patients. The follow-up duration was probably shorter in the included studies of this meta-analysis^[14] than that in our study, but the difference in the ONP recovery rate is massive with that in our study. If the follow-up time was long enough, the overall complete ONP recovery rate would probably increase to a similar level. In our study, it was also found that the surgical clipping group had a significantly shorter time of recovery and greater recovery rates at ≤ 12 months than those in the endovascular group. However, at 18 months follow-up, the recovery rate of ONP was not significantly different between the 2 groups. This may indicate that with time, thrombosis leads to continued shrinkage of the coiled aneurysm dome, eliminating aneurysm pulsation and compression on the oculomotor nerve in aneurysms treated with coil embolization, which is beneficial to complete recovery of ONP.

Some factors may affect the recovery of ONP. The study by Liu et al^[13] suggested that the time from ONP symptom onset to treatment, treatment approaches, subarachnoid hemorrhage caused by aneurysm rupture, and degree of nerve damage were factors to significantly affect the recovery of ONP. In the early stage of ONP when the function of the oculomotor nerve is in the status of reversible conduction block and neurapraxia and the injury of the nerve is relatively mild, timely treatment may quickly improve the function of the oculomotor nerve, resulting in faster recovery of ONP. Moreover, aneurysm rupture causes subarachnoid hemorrhage and blood clots, which may irritate, compress, and damage the oculomotor nerve, leading to ONP. Early surgical treatment can also eliminate the subarachnoid hemorrhage and prevents cerebral vasospasm caused by aneurysm rupture. The severity of ONP may influence the recovery effect of ONP. For some patients, the symptoms of ONP start to improve within 1 month after treatment and may be fully recovered 3–4 months later. However, if the ONP disease course lasted over 1 year, the oculomotor function may not be fully recovered.^[17] A longer follow-up time is thus necessary for patients with a longer history of ONP, and some patients may have complete recovery of ONP within 2 years after surgery.^[4] However, researchers also reported that ONP recovery was not significantly correlated with aneurysm size, treatment time, preoperative ONP severity, duration from ONP symptom onset to treatment, and subarachnoid hemorrhage.^[12] Further studies are needed to completely investigate the factors to affect the ONP recovery.

In surgical clipping, the aneurysm can be shaped by cauterization, and the aneurysm dome can be partially or completely removed by blood aspiration in the aneurysm sac and resection. This surgical approach can effectively eliminate the mechanical damage of the aneurysm to the oculomotor nerve and promote quick improvement of ONP, beneficial to quicker recovery. In endovascular embolization based on continuous development of related technologies, the vital signs of patients during operation are more stable, and the risk of complications is further reduced with the optimization of endovascular instruments, which has enabled increasing application of endovascular

treatment for intracranial aneurysms. Microsurgical clipping of aneurysmal neck may be better for quick ONP recovery, however, surgical clipping may not be suitable for complex, multiple or posterior circulation aneurysms, in which endovascular embolization may be better. Even though endovascular embolization may not result in quick and better recovery of ONP, endovascular embolization will ultimately lead to a similar ONP recovery rate in the long run.

Follow-up duration may affect the recovery rate of ONP. In our study, increasingly better recovery was achieved with a longer duration of follow-up, and 18 months after treatment demonstrated good recovery of ONP in both groups. In the study by Chalouhi et al^[8] using endovascular treatment for Pcom aneurysms complicated with ONP, ONP resolution was present in 33 (89.2%) patients at a mean follow-up duration of 11.3 months (range, 3–48 months). In univariate analysis, factors predictive of complete ONP recovery were increasing follow-up duration, complete aneurysm occlusion, and partial ONP palsy even though multivariate analysis revealed partial ONP palsy was the only independent predictive factor for complete ONP recovery.^[8] In the study by Signorelli et al who had treated 55 patients with unruptured Pcom aneurysms using either an endovascular or surgical approach,^[5] ONP was improved in only 40 patients (72.2%) even though most of patients (96.3% or 53 patients) had been followed up for over 1 year. This low recovery rate of 72.2% may be related to other reasons because, as stated above, the interval of ONP onset to the treatment, treatment approaches, subarachnoid hemorrhage caused by aneurysm rupture, and severity of ONP may all affect the recovery rate of ONP.^[13] Nonetheless, a longer term of follow-up will enable fibrosis and shrinkage of the treated and thrombosed aneurysm, resulting in decompression of the oculomotor nerve.

Some limitations existed in this study, including the retrospective and one-center study design, no randomization, Chinese patients enrolled only, and no study on ruptured aneurysms complicated with ONP. Moreover, factors affecting the recovery of ONP were not studied in our study. These issues may all affect the generalization of the outcome. Future studies will have to solve these issues for better outcomes.

In conclusion, surgical clipping may have a faster effect on the recovery of oculomotor nerve palsy than endovascular embolization for patients with posterior communicating artery aneurysms complicated with oculomotor nerve palsy, but both approaches may result in a similar effect on the nerve recovery in the long run.

Author contributions

Study design: Xun Shen, Bu-Lang Gao

Data collection: Xun Shen, Wenlei Wang, Huaihai Qin, Chun-Feng Ren

Data analysis: Xun Shen, Bu-Lang Gao

Supervision: Chun-Feng Ren

Writing of the original version: Xun Shen

Revision: Bu-Lang Gao

References

- [1] Golshani K, Ferrell A, Zomorodi A, et al. A review of the management of posterior communicating artery aneurysms in the modern era. *Surg Neurol Int.* 2010;1:88.
- [2] Tan H, Huang G, Zhang T, et al. A retrospective comparison of the influence of surgical clipping and endovascular embolization on recovery of oculomotor nerve palsy in patients with posterior communicating artery aneurysms. *Neurosurgery.* 2015;76:687–94; discussion 694.
- [3] Hall S, Sadek AR, Dando A, et al. The resolution of oculomotor nerve palsy caused by unruptured posterior communicating artery aneurysms: a cohort study and narrative review. *World Neurosurg.* 2017;107:581–7.

- [4] Kassis SZ, Jouanneau E, Tahon FB, et al. Recovery of third nerve palsy after endovascular treatment of posterior communicating artery aneurysms. *World Neurosurg.* 2010;73:11–6; discussion e2.
- [5] Signorelli F, Pop R, Ganau M, et al. Endovascular versus surgical treatment for improvement of oculomotor nerve palsy caused by unruptured posterior communicating artery aneurysms. *J Neurointerv Surg.* 2020;12:964–7.
- [6] Zhong W, Zhang J, Shen J, et al. Posterior communicating aneurysm with oculomotor nerve palsy: Predictors of nerve recovery. *J Clin Neurosci.* 2019;59:62–7.
- [7] Lv N, Yu Y, Xu J, et al. Hemodynamic and morphological characteristics of unruptured posterior communicating artery aneurysms with oculomotor nerve palsy. *J Neurosurg.* 2016;125:264–8.
- [8] Chalouhi N, Theofanis T, Jabbour P, et al. Endovascular treatment of posterior communicating artery aneurysms with oculomotor nerve palsy: clinical outcomes and predictors of nerve recovery. *AJNR Am J Neuroradiol.* 2013;34:828–32.
- [9] Zhang SH, Pei W, Cai XS, et al. Endovascular management and recovery from oculomotor nerve palsy associated with aneurysms of the posterior communicating artery. *World Neurosurg.* 2010;74:316–9.
- [10] Chen PR, Amin-Hanjani S, Albuquerque FC, et al. Outcome of oculomotor nerve palsy from posterior communicating artery aneurysms: Comparison of clipping and coiling. *Neurosurgery* 2006;58:1040–6; discussion 1040.
- [11] Yanovitch T, Buckley E. Diagnosis and management of third nerve palsy. *Curr Opin Ophthalmol.* 2007;18:373–8.
- [12] Gao G, Gu DQ, Zhang Y, et al. Comparison of the efficacy of surgical clipping and embolization for oculomotor nerve palsy due to a posterior communicating artery aneurysm. *Eur Rev Med Pharmacol Sci.* 2017;21:292–6.
- [13] Liu J, Peng C, Zhu G, et al. Comparison of surgical clipping and endovascular coiling in the treatment of oculomotor nerve palsy caused by posterior communicating artery aneurysm. *Medicine (Baltim).* 2020;99:e22969.
- [14] Gaberel T, Borha A, di Palma C, et al. Clipping versus coiling in the management of posterior communicating artery aneurysms with third nerve palsy: A systematic review and meta-analysis. *World Neurosurg.* 2016;87:498–506.e4.
- [15] Patel K, Guilfoyle MR, Bulters DO, et al. Recovery of oculomotor nerve palsy secondary to posterior communicating artery aneurysms. *Br J Neurosurg.* 2014;28:483–7.
- [16] McCracken DJ, Lovasik BP, McCracken CE, et al. Resolution of oculomotor nerve palsy secondary to posterior communicating artery aneurysms: comparison of clipping and coiling. *Neurosurgery.* 2015;77:931–9; discussion 939.
- [17] Hanse MC, Gerrits MC, van Rooij WJ, et al. Recovery of posterior communicating artery aneurysm-induced oculomotor palsy after coiling. *AJNR Am J Neuroradiol.* 2008;29:988–90.