Intracranial aneurysms presenting with mass effect over the anterior optic pathways: neurosurgical management and outcomes

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Object. Intracranial aneurysms may grow closer to anterior optic pathways, causing mass effect over these anatomical structures, including visual deficit. The authors retrospectively reviewed a series of aneurysms in patients presenting with visual field deficit caused by mass effect, to analyze the aneurysm's characteristics, the neurosurgical management of these aneurysms, as well as their clinical, visual, and radiological outcomes.

Methods. The authors reviewed the medical charts, neuroimaging examination results, and surgical videos of 15 patients presenting with visual symptoms caused by an aneurysm’s mass effect over the anterior optic pathways. These patients were treated at the Department of Neurosurgery, Center of Neurology and Neurosurgery Associates, Hospital Beneficência Portuguesa de São Paulo, Brazil. Statistical analysis was performed to identify the variables related to partial or total recovery of the visual symptoms.

Results. All patients underwent microsurgical clip placement and emptying of their aneurysms. After a mean follow-up of 38.5 months, the mean postoperative Glasgow Outcome Scale score was 4.33, and the visual outcomes were as follows: 1 patient (6.6%) unchanged, 7 (46.6%) improved, and 7 (46.6%) experienced complete recovery from visual deficits. The variables that influenced the visual outcomes were the size of the aneurysm (p = 0.039), duration of the visual symptoms (p = 0.002), aneurysm wall calcification (p = 0.010), and intraluminal thrombosis (p = 0.007). Postoperative examination using digital subtraction angiography showed complete aneurysm occlusion in 14 (93.3%) of the 15 patients.

Conclusions. Intracranial aneurysms causing mass effect over the anterior optic pathways usually present with complex features. The best treatment option must include not only the aneurysm occlusion but also relief of the mass effect. Microsurgical clip placement with reduction of aneurysmal mass effect achieved improvement in visual ability or recovery from visual impairment, as well as total aneurysm occlusion, in 93.3% of the study group. Therefore, this option is well supported as the first choice of treatment for intracranial aneurysms presenting with mass effect over the anterior visual pathways. (DOI: 10.3171/2009.3.FOCUS0924)

Key Words • aneurysm • optic pathways • mass effect • clipping • microsurgery • visual symptoms

Subarachnoid hemorrhage is the most common presentation of intracranial aneurysms. Nevertheless, the greater majority of intracranial aneurysms remain asymptomatic until rupture, with only 10% presenting prior to rupture, usually with symptoms of mass effect. The risk of subsequent bleeding of symptomatic unruptured aneurysms is greater than in asymptomatic aneurysms, and therefore should be considered for treatment not only to reduce the mass effect but also to avoid the risk of hemorrhage.

Due to the proximity of the circle of Willis with the anterior optic pathways, some aneurysms may grow closer to ONs, chiasma, optic tracts, or even optic radiations, causing mass effect over these anatomical structures and some degree of visual deficit. Although this situation has been described in ruptured small and posterior circulation aneurysms,11 unruptured large or giant aneurysms arising from the anterior circulation are most often responsible for this mass effect by compression of anterior optic pathways. We retrospectively analyzed our early experience with intracranial aneurysms presenting...
with mass effect over the anterior optic pathways to assess the aneurysm’s characteristics, the neurosurgical management of these aneurysms, as well as their clinical, visual, and radiological outcomes.

**Methods**

*Patient Population*

From March 2004 to April 2007, 158 patients with intracranial aneurysms were treated at the Department of Neurosurgery, Center of Neurology and Neurosurgery Associates, Hospital Beneficência Portuguesa de São Paulo, Brazil. We reviewed the medical charts and neuroimaging examination results of all patients with aneurysms presenting with visual deficits who were referred to microsurgical clip placement, as well as the operative reports and surgical videos. These data were prospectively added to a computer database of all patients treated for intracranial aneurysms at our institution. Fifteen (9.5%) of these

**TABLE 1: Summary data of demographics, aneurysm characteristics, and clinical presentation**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Location</th>
<th>Size (mm)</th>
<th>Calcification</th>
<th>Thrombus</th>
<th>Broad-Neck</th>
<th>Other An-</th>
<th>Fisher</th>
<th>Visual Field</th>
<th>Duration of VD</th>
<th>Other Signs &amp; Symptoms</th>
<th>GOS Score</th>
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<td>no</td>
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<td>yes</td>
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<td>no</td>
<td>no</td>
<td>0</td>
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</table>

* HH = Hunt & Hess classification; VD = visual deficit.
patients presented with visual field deficits caused by the mass effect of an aneurysm over any point on the anterior optic pathways, and were selected for this study.

The following variables were carefully reviewed: demographics (age and sex), aneurysm characteristics (location, size, calcification, thrombus, broad neck, and multiple aneurysms), clinical presentation (SAH, Fisher grade, Hunt and Hess classification, visual field deficit, duration of visual field deficit, other signs and symptoms, and GOS score), intraoperative findings (site of compression over the visual pathways), neurosurgical management, complications, clinical outcome (GOS score), visual outcome (postoperative and last examination), radiological outcome (occlusion rate on postoperative DS angiography), and follow up (months).

**Patient Characteristics**

The clinical and radiological features of the patients are summarized in Table 1. Ten patients (67%) were female and 5 (33%) were male. The age of the patients ranged from 35 to 78 years (mean 51.4 ± 11 years). The neuroophthalmological examinations with campimetry studies were performed preoperatively and postoperatively (immediately and at the last follow-up evaluation). The visual field deficits were extremely variable in each patient and are described in Table 1. The duration of the visual field deficit ranged from 1 to 12 months (mean 5.6 ± 4.2 months). Among the 15 patients, 5 presented with SAH, and 10 without. Clinically, the patients were assessed according to the GOS and the mean preoperative score was 4.5 (range 3–5). Other signs and symptoms presented included headache (80%), syncope (13%), epilepsy (13%), hemiparesis (13%), hemiplegia (13%), aphasia (13%), and dizziness (6.6%).

**Aneurysm Characteristics**

Five patients harbored ruptured aneurysms and 10 harbored unruptured aneurysms. Regarding the location
of the aneurysms, 8 were paraclinoidal (Figs. 1–6), 5 from the ACoA (Figs. 7 and 8), 1 from the MCA, and 1 from the bifurcation of the ICA. The mean size of the aneurysms was 19.8 mm (range 10–30 mm; Table 1). Eight (53.3%) aneurysms presented with calcifications and 6 (40%) of these calcified lesions were partially thrombosed. Eleven
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(73.3%) aneurysms presented with a broad neck, and 4 patients presented with multiple aneurysms.

**Neurosurgical Approach**

Under general anesthesia, all patients were placed supine in a 3-point fixation device. For aneurysms arising from the ICA bifurcation, MCA, and ACoA, we positioned the patient’s head with greater extension and minor rotation, whereas for paraclinoidal aneurysms we used minor or absent extension with greater rotation. For paraclinoidal aneurysms, the first step was to access the ICA at the cervical level to achieve proximal control. A standard pterional craniotomy was performed with a wide opening of the sylvian fissure to avoid brain retraction. Also for paraclinoidal aneurysms, we performed falciiforme ligament opening to allow a safer mobilization of the ON. In addition, the ACP and optic strut were removed (always intradurally) using a high-speed diamond-tipped drill under continuous saline solution irrigation to achieve exposition of the clinoidal segment of the ICA (Figs. 5B–D). A careful dissection was performed to identify both the proximal and distal aneurysm neck as well as the branching arteries. At this stage trapping of the parental artery, with or without suction, can be helpful in large or giant aneurysms and those with atherosclerotic plates, thrombosis, or calcification. All aneurysms were punctured and emptied using suction to achieve enough decompression of visual pathways. In cases of mass effect caused by calcification and or a thrombus, the aneurysms were also opened and emptied (aneurysmatomy; Figs. 5E and 6E). For aneurysms presenting with a broad neck, for which occlusion required artery reconstruction, we used multiple fenestrated clips with different configurations (Fig. 6E).

When temporary occlusion of the parental artery was required or judged helpful to make the decompression and clip placement easier, it was performed by occluding the parental artery with temporary clips proximal and distal to the aneurysm’s origin (trapping) for 3 to 5 minutes, followed by opening and emptying of the aneurysm. In those cases in which multiple temporary clips were required, the aneurysm’s opening, performed to empty the aneu-
rysm or to remove calcifications and thrombi, was occluded with clips. The temporary clips used for the trapping were then removed to reestablish the flow for 3–5 minutes, after which a new sequence of temporary clip placement was performed, again with a duration of 3–5 minutes. This protocol was repeated until the optic pathways were decompressed and the aneurysms completely occluded by definitive clips. All patients were operated on by the first author (J.G.O.).

**Statistical Analysis**

To identify the variables related to visual outcome, 2 groups were created according to the last visual examination. Group 1 was composed of those cases whose outcomes were “unchanged” or “improved”, while Group 2 consisted of patients who achieved complete “recovery” from visual symptoms. The statistical analysis was performed between the 2 groups using the Student t-test for the variables of age, aneurysm size, and duration of visual symptoms; the Fisher exact test was used for the variables of aneurysm location, aneurysm wall calcification, and presence of intraluminal thrombus. With regard to the aneurysm location, we divided our patients into “paraclinoidal” and “other location” groups. Statistical significance was assumed when the probability value was < 0.05.

**Results**

All patients underwent microsurgical clipping of their aneurysms, and in 7 patients aneurysmotomy was performed to remove wall calcification or an intraluminal thrombus; additionally, the remaining aneurysms were punctured and the blood was suctioned to alleviate the mass effect. We did not experience any intraoperative rupture of the aneurysms in this patient series. Therefore, temporary clip placement was required in 4 instances in which the parental artery was occluded before and after the origin of the aneurysm (trapping) to make decompression and the aneurysm clipping easier (Cases 9, 10, and 14). Although we achieved proximal control of the cervical ICA, the temporary clipping of the ICA was performed after exposition of the clinoidal segment, which allowed an intracranial proximal occlusion. For Case 15, who had an ACoA aneurysm, temporary clipping was performed with occlusion of both A1 and A2 bilaterally. For Cases 5, 6, and 11, the aneurysmotomy was performed after the aneurysm clipping, and temporary clipping was unnecessary. According to the intraoperative findings, the sites of compression over the visual pathways were absolutely congruent with the visual field impairment (Tables 1 and 2).

After a mean follow-up of 38.5 months (range 2–52 months), the mean postoperative GOS score was 4.33. Eleven patients (73.3%) were clinically unchanged when compared with the preoperative GOS score, while 2 (13.3%) worsened and 2 (13.3%) improved. Among the patients whose GOS scores worsened, both had ischemic stroke late in the postoperative period, and 1 of them had a vascular acute abdomen (mesenteric thrombosis), which led to her death. In addition to these 2 patients with stroke, another patient experienced complications from a CSF leak, which resolved spontaneously.

Regarding the immediate postoperative visual outcome, 2 (13.3%) patients worsened, 10 (66.6%) were unchanged, and 3 (20%) improved (Table 2). However, after the mean follow-up of 38.5 months, 1 patient (6.6%) remained unchanged, 7 (46.6%) improved in their preoperative visual impairment, and 7 (46.6%) showed complete recovery of their visual deficits.

The statistical analysis of the variables related to the visual outcomes revealed that patient age (p = 0.404) and aneurysm location (p = 0.619) were not significantly different between Groups 1 and 2. Nevertheless, the size of the aneurysms in Group 1 was significantly larger than...
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Discussion

Aneurysms Characteristics and Patterns of Visual Field Loss

The incidence of unruptured intracranial aneurysms presenting with mass effect ranges between 8 and 25%.

Although visual symptoms may be present in aneurysms of small size; they usually appear in patients with large and giant aneurysms. In our patient series, 86.6% of the aneurysms were large or giant, with a mean size of 19.8 mm.

Aneurysms presenting with mass effect over the optic pathways commonly arise from the paraclinoidal segment, ACoA, and ICA bifurcation. Nevertheless, several studies have reported aneurysms in any portion of the circle of Willis producing compression over the visual pathways. Although paraclinoidal aneurysms represent only 5% of intracranial aneurysms, they are the most common cause of visual complaints caused by aneurysm compression of the ON and chiasm. In this study, paraclinoidal (in 8 patients) and ACoA (in 5 patients) aneurysms also represented the majority of the cases (86.6%).

Similar to other slow-growing lesions causing mass effect over the anterior optic pathways, the patients may
not realize the extent of their visual deficit and usually present with symptoms of headache and orbital pain. Internal carotid artery aneurysms usually compress the ipsilateral ON or chiasm from below, leading to a unilateral or bitemporal hemianopia. Most of our patients (40%) presented with this kind of visual deficit caused by compression over the ONs (Cases 5, 9, 11, 12, 13, and 15). When the compression is more anterior, a junctional scotoma may be present, with ipsilateral paracentral scotoma progressing to complete visual loss and contralateral temporal quadrant anopia or hemianopia. We observed this situation in only 1 case (Case 4).

Although aneurysms arising from ICA bifurcation usually present with visual signs and symptoms caused by compression of the ipsilateral posterior ON or chiasm, those cases that projected posteriorly may cause optic tract compression. The only ICA bifurcation aneurysm in our patient series was projected posteriorly, which caused the patient to present with a right homonymous hemianopia (Case 3).

Visual symptoms may be present in more than 25% of the patients with ACoA aneurysms and there are several patterns of visual loss. Among the 5 patients presenting with ACoA aneurysms, 4 were compressing the chiasma and 1 was causing mass effect over the left ON. Bitemporal hemianopia was found in 2 patients, while the others presented with some degree of ipsilateral hemianopia.

**Mechanisms of Visual Loss**

The main cause of visual impairment is supposed to be direct compression of the visual pathways by the aneurysms, which supports the use of microsurgical decompression of the visual pathways as mandatory treatment. On the other hand, other investigators suggest that the pulsation of the aneurysm would be the most important cause of visual deficit, which could explain the good results from endovascular occlusion. However, the blood supply of the optic pathways may also be compromised by occlusion or kinking of the OphA. In addition, some aneurysms, especially paraclinoidal ones, may cause indirect compression of the ON against the optic canal and then cause visual disturbance (Fig. 6D).

Acute visual loss may also be caused by ocular hemorrhage in association with SAH. The 3 types of ocular hemorrhage are subhyaloid ( preretinal), (intra) retinal, and hemorrhage within the vitreous humor (Terson syndrome). These types occur alone or in combination in 20–40% of patients with SAH. The exact mechanism by which this occurs is unclear. It is likely caused by subarachnoid blood moving into the optic sheath or due to outflow obstruction from the sudden rise in intracranial pressure, causing venous engorgement and hemorrhage. Among the 5 patients with SAH in our patient series, none presented with Terson syndrome.
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Variables Related to Visual Outcomes

Because paraclinoidal aneurysms have a close relation with bone structures of the skull base, it is reasonable to suppose that the mechanism of visual loss is not only due to the aneurysm mass effect but also to the compression of the ON against the optic canal (Fig. 6D) or compromising of the vascular supply (OphA). Therefore, we hypothesized that aneurysms in other locations (such as the ACoA, ICA bifurcation, and MCA) could have better visual outcomes when compared with paraclinoidal aneurysms. Nevertheless, this hypothesis was not confirmed by our statistical analysis (p = 0.619).

Aneurysms presenting with mass effect over the optic pathways are frequently large or giant in the great majority of the patient series in the literature. In our patient series, 86.6% of the aneurysms were large or giant. In addition, the size of the aneurysms was a significant variable in relation to visual outcome, in which the mean aneurysm size in the group that experienced improvement was 22.5 mm compared with 16.7 mm in the group that experienced recovery of visual symptoms (p = 0.039).

The duration of symptoms (from the onset of symptoms until treatment) appears to be one of the most significant variables related to visual outcome. In our patient series, 86.6% of the aneurysms were large or giant. In addition, the size of the aneurysms was a significant variable in relation to visual outcome, in which the mean aneurysm size in the group that experienced improvement was 22.5 mm compared with 16.7 mm in the group that experienced recovery of visual symptoms (p = 0.039).

Alternative Therapeutic Options for Aneurysms Causing Mass Effect

Currently, aneurysm occlusion for cases in which mass effect is present may be achieved by procedures that also occlude the parental artery (deconstructive) or by procedures in which the parental artery is preserved (reconstructive); both can be performed microsurgically, endovascularly, or in combination. Some authors have described good results using Hunterian or parental artery occlusion (deconstructive) related to relief of mass effect symptoms. When a deconstructive procedure is planned, an excellent preoperative evaluation of the

Fig. 8. Case 15. Intraoperative microsurgical images (A–C) and postoperative DS angiograms (D–F). A and B: Anterior communicating artery aneurysm (AN) compressing the left ON. C: View after aneurysm clipping and aneurysmotomy with emptying of the intraluminal content, leading to a complete decompression of the ON. D–F: Digital subtraction angiograms showing complete occlusion of the aneurysm.
cerebral blood flow must be accomplished to predict the need of a blood flow augmentation through bypass techniques.\textsuperscript{2,19,29,30}

The goal of any method used for treating intracranial aneurysms is total occlusion to avoid SAH and aneurysm growth. However, for aneurysms presenting with mass effect, a single occlusion is usually not sufficient to relieve the symptoms, and decompression techniques may be required. All patients in our series had their aneurysms punctured and emptied by suction or aneurysmotomy with removal of wall calcification and the intraluminal thrombus, which made the clipping easier, with improvement or resolution of visual symptoms in all but 1 patient (93.3%) and total aneurysm occlusion in 14 (93.3%) of 15 cases.

Endovascular techniques for aneurysm occlusion and preservation of the parental artery have been used in patients presenting with mass effect symptoms with intriguing results. Vargas et al.\textsuperscript{31} treated 19 giant aneurysms causing visual loss using detachable balloons in 12 patients and with GDCs in 7 patients; none of the patients experienced complete recovery of visual symptoms, 7

\textbf{TABLE 2: Summary data concerning site of compression, neurosurgical management, clinical and radiological outcomes, and follow-up}

<table>
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<th>Visual Outcome</th>
<th>Radiological Outcome (%)\textsuperscript{‡}</th>
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<td>improved recovery</td>
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<td>50, F</td>
<td>rt optic nerve</td>
<td>clip placement</td>
<td>no</td>
<td>5</td>
<td>unchanged recovery</td>
<td>100</td>
<td>37</td>
</tr>
<tr>
<td>14</td>
<td>42, M</td>
<td>lt optic nerve and chiasma</td>
<td>clip placement, aneurysmotomy</td>
<td>no</td>
<td>5</td>
<td>unchanged improved</td>
<td>100</td>
<td>19</td>
</tr>
<tr>
<td>15</td>
<td>55, F</td>
<td>lt optic nerve</td>
<td>clip placement, aneurysmotomy</td>
<td>stroke, mesenteric thrombosis, death</td>
<td>1</td>
<td>unchanged improved</td>
<td>100</td>
<td>2</td>
</tr>
</tbody>
</table>

\textsuperscript{*} Site of compression based on intraoperative and radiological findings.
\textsuperscript{†} Numbers in parentheses refer to number of temporary clipping events.
\textsuperscript{‡} Radiological outcome based on aneurysm occlusion rate on DS angiography.
Intracranial aneurysms compressing anterior optic pathways

### TABLE 3: Summary data regarding variables statistically analyzed

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group 1</th>
<th>Group 2</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean patient age (yrs)</td>
<td>53.8</td>
<td>48.7</td>
<td>0.404</td>
</tr>
<tr>
<td>% w/ paracinealoidal location</td>
<td>62.5</td>
<td>37.5</td>
<td>0.619</td>
</tr>
<tr>
<td>mean aneurysm size (mm)</td>
<td>22.5</td>
<td>16.7</td>
<td>0.039</td>
</tr>
<tr>
<td>mean duration of symptoms (mos)</td>
<td>8.4</td>
<td>2.4</td>
<td>0.002</td>
</tr>
<tr>
<td>% w/ calcification</td>
<td>87.5</td>
<td>12.5</td>
<td>0.010</td>
</tr>
<tr>
<td>% w/ thrombus</td>
<td>100</td>
<td>0</td>
<td>0.007</td>
</tr>
</tbody>
</table>

* Group 1 = unchanged or improved; Group 2 = recovery.

(36.8%) improved, 11 (57.8%) remained unchanged, and 1 (5.2%) worsened, in addition to the occurrence of complications in 8 patients (42%). Halbach et al.13 endovascularly treated 26 patients with aneurysms and mass effect, but only 8 showed visual acuity or field deficits. After a mean follow-up of 58.5 months, none of their 8 patients presented with resolution of visual symptoms, 6 (75%) improved, and 2 (25%) remained unchanged; residual aneurysm filling was noted in 6 (75%) of the 8 patients.

Malisch and colleagues21 used GDCs to treat 19 patients with mass effect symptoms, but only 8 had visual field impairment. Among these 8 patients, none had resolution of visual symptoms, 1 (12.5%) worsened, 3 (37.5%) remained unchanged, and 4 (50%) improved after a mean follow-up of 20.1 months. Furthermore, 2 patients (25%) required an additional microsurgical procedure. In the conclusion of their work the authors recommended GDCs as an alternative treatment stating, “In those cases in which giant aneurysms can be surgically obliterated with acceptable risks of morbidity and mortality, that approach remains the treatment of choice because GDC treatment of giant aneurysms does not appear to offer the same durability of protection from rupture.”

Using endosaccular coils, Heran et al.14 treated 16 patients with large ophthalmic aneurysms compressing the anterior optic pathways. After the initial endovascular procedure, complete occlusion of the aneurysm was achieved in only 2 patients (12.5%). The researchers evaluated 12 patients using angiography and found some degree of coil compaction in 10 patients (83.3%) after a mean duration of 1.5 years, which led to 13 additional procedures (5 patients underwent repeat coil embolization [1 of them twice], and 7 ICA occlusions were performed) in 12 patients (70.5%). Among the 5 aneurysms that were treated using repeat coil embolization, only 1 achieved complete occlusion, and among the 7 patients whose carotid arteries were occluded, 6 achieved complete aneurysm occlusion. Regarding the visual outcomes after the primary endovascular procedure, the authors described improvement in 38%, no change in 25%, and worsening in 38%; after subsequent procedures (including microsurgery in 3 cases) they achieved improvement in 31%, and saw no change in 19% and worsening in 19%. No patients achieved complete recovery of visual symptoms. Furthermore, in this study, 2 patients died after coil therapy for SAH from rupture of the coil-treated aneurysm. In the discussion section of this paper the authors stated, “Microsurgical clip therapy is often preferred in patients with acute or subacute visual loss in whom immediate decompression can result in more rapid visual improvement. In patients with surgically accessible aneurysms that are wide necked but not calcified and have minimal or no extension into the cavernous sinus, or in cases involving smaller aneurysms, microsurgery may be preferred. Surgical clip application or a bypass procedure may be the best therapeutic option in a patient in whom carotid occlusion cannot be tolerated.”

From our point of view, the only mechanism to explain any improvement after endovascular coil packing would be the reduction of pulsation over the fundus of the aneurysms. However, the pathophysiology of the mass effect and visual impairment is multifactorial, which led us to believe that it is unreasonable to suppose that inducing intraluminal thrombosis by endovascular techniques could alleviate mass effect symptoms, because in some cases it is mandatory to open and remove the thrombus from within the aneurysms. On the contrary, several reports show worsening of mass effect symptoms after endovascular treatment.7,21,26 Yu et al.24 analyzed the distensibility of aneurysms treated with coil embolization and concluded that the degree of distension may be as high as 34.2% of the initial aneurysm volume. Older as well as recent publications have described an inflammatory reaction and edema after endovascular coiling, increasing the mass effect around the aneurysms and consequently worsening the symptoms.13,17,26

### Conclusions

Intracranial aneurysms causing mass effect over the anterior optic pathways are usually complex, presenting with large or giant sizes, wall calcification, intraluminal thrombus, and broad necks. The decision-making process with regard to the best treatment must consider not only the aneurysm occlusion but also relief of the mass effect. Our patient series showed that aneurysm size, calcification, intraluminal thrombus, and, especially the duration of the visual symptoms are important variables related to the visual outcome. We performed microsurgical clip placement in all patients with a subsequent reduction of aneurysmal mass effect, which led to 93.3% improvement in or recovery of visual impairment and 93.3% of total aneurysm occlusion, with acceptable rates of morbidity and mortality. Based on our early experience and the results in the literature, we recommend microsurgical clip placement as the first choice for intracranial aneurysms presenting with mass effect over the anterior visual pathways.

### Disclaimer

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.
References