Case Report

Two patients of visual disturbance and optic perineuritis after placement of a flow diverter

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ABSTRACT

The pathogenesis of new visual symptoms after flow diverter stent placement in the ophthalmic artery for internal carotid artery aneurysms remains unclear. We report two cases of patients who developed visual field disturbance and decreased visual acuity following flow diverter placement. The “doughnut sign” was found around the optic nerve on magnetic resonance imaging.

The patients had progressive visual field defects and impairment on the side where the flow diverter was placed. Short tau inversion recovery coronal images showed a doughnut-shaped high-signal area around the optic nerve on the affected side. Both patients were treated with steroid pulse therapy, and 1 received endovascular therapy. Their symptoms gradually improved, and the “doughnut sign” disappeared.

The “doughnut sign” observed around the optic nerve on magnetic resonance imaging may be found alongside visual disturbance symptoms after paraclinoid aneurysm treatment.

It is recommended that short tau inversion recovery sequences be performed preoperatively in patients presenting with visual impairment and in whom the possibility of postoperative exacerbation is suspected.

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Introduction

Flow diverter (FD) stents are effective in treating large aneurysms with neurological symptoms, showing a postoperative improvement rate of 58% for clipping, 49% for coil embolization, and 71% for FD placement in patients with postoperative visual symptoms [1].

The incidence of new visual symptoms after treatment was 3.0% in a meta-analysis of FD placement in the ophthalmic artery for internal carotid (IC) artery (ICA) aneurysms [2]; however, the pathogenesis of these new symptoms remains unclear. We report 2 cases of patients who developed visual field disturbance and decreased visual acuity following FD placement with coil embolization. The “doughnut sign” was observed around the optic nerve on magnetic resonance imaging (MRI).

Case report

Case 1

A Flow Redirection Endoluminal Device (FRED) 5.0 (working length, 14 mm; total length at labeled diameter, 21 mm) (MicroVention, Inc., Aliso Viejo, CA) was implanted for the treatment of a left IC-ophthalmic aneurysm (maximum diameter, 12 mm) in a 49-year-old woman. 3 coils were roughly packed for embolization due to a history of right IC-posterior communicating aneurysm rupture (Fig. 1A).

On the third postoperative day, the patient became aware of difficulty in seeing in the nasal aspect of the left eye. In about a week, it progressed to visual field defects in the entire visual field. (Fig. 1B). Fluorescence fundus examination revealed no abnormalities. On MRI, the left optic nerve was deviated due to the enlarged aneurysm and it featured a doughnut-shaped high-signal area on the coronal short tau inversion recovery (STIR) sequence (Fig. 1B). The patient was treated with one course of steroid pulse therapy (Methylprednisolone Sodium Succinate (Solu-Medrol for Intravenous Use®, Pfizer Japan Inc., Shibuya, Tokyo, Japan) 1000 mg/day for 3 days).

Her visual acuity improved after about 3 months. However, a slight upper right quadrantanopia persisted (Fig. 1C). After one year of treatment, STIR coronal images showed that the “doughnut sign” had disappeared. (Fig. 1C).

Case 2

A 57-year-old woman presented with impaired right visual acuity and visual field, and she was diagnosed with a paraclinoid aneurysm with a maximum diameter of 14 mm. Pretreatment MRI showed that the optic nerve was already compressed by a right paraclinoid aneurysm. FD placement (FRED 4.0; working length, 26 mm; total length at labeled diameter, 32 mm; MicroVention, Inc.) and embolization using 5 coils was performed (Figs. 2A and 2B).

The visual field impairment progressed gradually after 1 month of treatment. Steroid pulse therapy (solumedrol

![Fig. 1](image_url) – Images of case 1 (A): Angiography before coil and stent placement (upper image). The ophthalmic artery is seen in the dome of the aneurysm. Postoperative cone beam computed tomography (CBCT) shows coils and flow diverter stent within the aneurysm (lower image). (B): MRI STIR coronal image and visual field during symptom worsening. The “doughnut sign” around the left optic nerve is seen, and the visual field shows almost total anopsia. C: MRI STIR coronal images and visual field after symptom improvement. The “doughnut sign” around the left optic nerve has disappeared.
methylprednisolone 1000 mg/day) was administered from postoperative day 60 to day 123; however, there was little improvement.

On postoperative day 122, orbital T1-weighted coronal MRI revealed high-signal findings suggestive of thrombosis in the mass. The STIR coronal image revealed a doughnut-shaped high-signal area around the left optic nerve (Fig. 2C).

Increased blood flow and enlargement of the aneurysm was observed on angiography, and a FRED 3.5 (working length, 11 mm; total length at labeled diameter, 17 mm; MicroVention, Inc.) was implanted on postoperative day 133 (Fig. 2B). The visual field impairment improved gradually after the re-treatment, and the “doughnut sign” disappeared from the orbital STIR coronal image at 156 days after the second FRED (FRED 3.5; working length, 11 mm; total length at labeled diameter, 17 mm; MicroVention, Inc.) implantation (Fig. 2C).

**Discussion**

The occurrence of visual symptoms following FD placement can be due to several reasons, such as cerebral infarction, black cataract, or retinal embolism. Occlusion of the origin of the ophthalmic artery can cause ischemia in patients with these conditions [2,3]. Visual symptoms caused by these factors occur intraoperatively or immediately after treatment, and their response to steroids is considered poor [4]. Other causes include post-treatment aneurysm enlargement (exacerbation of the mass effect), inflammation due to the thrombus, and arterial wall inflammation [4], and these may in turn cause compression of the optic nerve and result in visual symptoms [5]. The condition is slow onset, progressive, and considered highly responsive to steroids [4,5], but there are few reports on imaging findings.

No retinal ischemia or cerebral infarction was present in these cases; however, postoperative thrombosis and regrowth of the aneurysms worsened the mass effect, and the MRI STIR coronal images showed a high-signal ("doughnut sign") around the optic nerve. The optic nerve is encircled by the arachnoid and soft membranes intracranially, but the membranes transition from the meninges (dura mater, arachnoid, and soft membranes) to the optic nerve sheath in the optic tract. Cerebrospinal fluid perfuses between the optic nerve sheath and the optic nerve.

The "doughnut sign" on the coronal images and the "tram-track sign" on the axial images in orbital MRI indicate optic perineuritis [6,7] or impaired perfusion of spinal fluid around the optic nerve due to compression. It causes symptoms such as ocular pain, visual disturbance, papilledema, eye movement disturbance, and eyelid drooping. Causes of optic perineuritis include antineutrophil cytoplasmic antibody (ANCA)-associated vasculitis, hypertrophic pachymeningitis, allergic granulomatous vasculitis (Churg-Strauss syndrome), granulomatosis with polyangiitis, and anti-GQ1b antibody syndrome, as well as systemic inflammatory diseases such as...
as Bickerstaff’s brainstem encephalitis, osteodysplastic syndrome, aseptic meningitis, and liver cancer [6]. Idiopathic and secondary recurrences are frequent; however, their response to steroids is good.

In our cases, the mass effect caused by thrombosis and enlargement of the aneurysm impaired perfusion of cerebrospinal fluid around the optic nerve, and the inflammation spread to the optic nerve sheath, resulting in optic perineuritis. Both cases presented with severe visual symptoms, but the visual prognosis was good after steroid administration and stent implantation. To our knowledge, this is the first case report of a “doughnut sign” around the optic nerve on MRI, indicating the worsening of the mass effect and inflammation after aneurysm treatment.

The present study was limited in that MRI STIR was not performed preoperatively. It is recommended that preoperative MRI STIR should be considered in patients with preoperative visual impairment and expected postoperative deterioration.

**Conclusion**

MRI findings of the “doughnut sign” were observed in 2 patients with visual symptoms associated with FD placement and coil embolization. This finding is thought to be caused by optic perineuritis due to inflammation spreading to the optic nerve sheath or by impaired perfusion of the spinal fluid around the optic nerve.

MRI scans should be performed in patients with visual symptoms associated with perioperative period of endovascular treatment for ICA paraclinoid aneurysm. If the “doughnut sign” or “tram-track sign” is observed, appropriate treatment such as steroid administration or re-treatment of the aneurysm should be considered.

This is the first report of the “doughnut sign” in two patients with post-treatment visual symptoms, but we believe that more cases need to be accumulated.

**Patient consent statement**

Informed consent for patient information to be published in this article was obtained.

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