Gamma knife radiosurgery as an alternative treatment of Barrow type B carotid cavernous fistulas
A case report
Kang-Hoon Park, MD, Jung-Soo Park, MD, PhD*, Eun-Jeong Koh, MD, PhD, Jong-Myong Lee, MD

Abstract
Rationale: Barrow type B carotid-cavernous fistulas are dural shunts between the meningeal branches of the internal carotid artery and the cavernous sinus; these types of dural fistulas can produce specific patterns of symptoms based on the pattern of venous drainage.

Patient concerns and diagnoses: A 67-year-old man came to our hospital presenting with acute left orbital pain and double vision in the left eye. The diagnosis was carotid-cavernous fistula fed by the meningohypophyseal trunk and drained to the left superior ophthalmic vein.

Interventions and outcomes: We planned gamma knife radiosurgery for the left cavernous sinus including fistula point as an alternative treatment. The orbital pain disappeared in 2 weeks, and all signs and symptoms in the left eye completely improved within 2 months.

Lessons: Gamma knife radiosurgery may be an alternative treatment for carotid cavernous fistula. Furthermore, in patients with poor vascular access and no fatal presentation, this may be a reasonable first-line treatment option.

Abbreviations: CCF = carotid cavernous fistula, GKRS = gamma knife radiosurgery, IPS = inferior petrous sinus, MRI = magnetic resonance imaging, SOV = superior ophthalmic vein.

Keywords: Barrow classification, carotid-cavernous fistula, gamma knife radiosurgery

1. Introduction
Carotid cavernous fistulas (CCFs) are abnormal communications between the carotid artery and the cavernous sinus. Previously, Barrow et al[1] classified them as direct or indirect according to their angiographic features; type B CCFs are dural shunts between the meningeal branches of the internal carotid artery and the cavernous sinus. Because of the direct shunting of arterial blood into the cavernous sinus and subsequently into the superior ophthalmic vein (SOV), patients who have these fistulas often present with ocular bruit, blurred vision, headache, diplopia, ocular pain, proptosis, conjunctival injection, seizure, and neurologic deficit.[1,2] Endovascular treatment with coils, stents, and liquid embolic agents through transarterial or transvenous routes remains the first-line treatment option for uncontrolled symptomatic or hemorrhagic CCFs.[3] However, endovascular approaches for CCFs are not always possible, safe, or effective because of poor vascular access, risk of retrograde flow of embolic materials, and partial embolization.[4,5] Recently, stereotactic radiosurgery has been attempted as an alternative treatment option for patients with CCFs who are at high risk of endovascular treatment.[4,6,7] Herein, we report a case of a patient with Barrow type B CCF who was successfully treated with gamma knife radiosurgery (GKRS).

2. Case report
A 67-year-old man with no past medical history visited our emergency room presenting with acute left orbital pain and double vision in the left eye on December 15, 2017. Ophthalmological examination showed chemosis, conjunctival injection, exophthalmos with mild proptosis, and an intraocular pressure of 23 mm Hg in the left eye (Fig. 1). Brain magnetic resonance imaging showed exophthalmos with dilated SOV in the left eye (Fig. 2). He was admitted to neurosurgery for interventional neuroradiology under suspicion of CCF.

On December 18, 2017, cerebral angiography was performed. Left internal carotid artery angiography showed
a CCF (Barrow type B), which was fed by the meningohypophyseal trunk and drained to the left SOV (Fig. 3). Initially, we planned endovascular embolization, but the caliber of the meningohypophyseal trunk was very small, so we thought that a transarterial route was not possible. The transvenous approach via the inferior petrous sinus (IPS) also seemed to be difficult because we could not see the IPS even in the delayed venous phase. Because the patient’s condition was not fatal, we thought that surgical exposure via SOV would be invasive considering the complaints. Therefore, we planned GKRS with Leksell Gamma Knife Perfexion (Elekta Instruments, AB, Stockholm, Sweden) for the left cavernous sinus including fistula point as an alternative treatment. The patients received GKRS at 18 Gy to the 50% isodose line based on the radiation dose applied to intracranial arteriovenous malformations on December 22, 2017 (Fig. 4). The orbital pain disappeared in 2 weeks, and all signs and symptoms in the left eye improved completely within 2 months (Fig. 5). On July 5, 2018, a follow-up angiography was performed that showed complete closure of the fistula with no visible engorged SOV (Fig. 6).

3. Discussion

Based on angiographic characteristics, CCFs were classified by Barrow et al[11] into type A, B, C, or D. Type A fistulas are abnormal direct communications between the carotid artery and the cavernous sinus. Type B, C, and D fistulas are indirect communication cavernous sinuses with dural feeders from the internal or external carotid artery.

Endovascular treatment through transarterial or transvenous routes remains the first treatment option for CCFs.[3-5] However, endovascular treatment is not always possible or safe. In patients with tortuous or atherosclerotic arteries, a transarterial approach may be challenging, or procedure-related complications such as distal emboli or vascular injury may result.[3,8] The IPS is the most commonly used route for transvenous approaches.[3,5] However, these routes are restricted when there are thromboses in the IPS or no communication between the IPS and the fistula site.[8,9] The SOV is another route for a transvenous approach, but this procedure requires an invasive upper eyelid cut-down and may not be possible if the SOV does not dilated or located deep in the orbit.[10]

Recently, because of the possible risks and complications with endovascular treatment of patients with CCF, alternative treatments such as flow diverter stents and stereotactic radiosurgery have been proposed with favorable outcomes.[4,6,7,11] There are some advantages of GKRS as an alternative treatment for CCF compared with endovascular embolization. First, it is possible even in cases of poor vascular access such as tortuous or atherosclerotic arteries, occluded IPS, or deep located SOV. Second, GKRS can minimize procedure-related complications; it does not entail directly manipulating blood vessels, and, it can reduce radiation to normal neuronal tissue adjacent to the cavernous sinus by detailed demarcation of the lesion area in the planning process. Third, if the patient’s symptoms are tolerable, other adjuvant treatment option can be planned later.

Although it may not be appropriate in patients who need immediate symptom relief, GKRS may be an alternative treatment for selective CCF patients. Furthermore, in patients
Figure 3. Lateral left internal carotid artery angiogram on December 18, 2017, demonstrates an indirect carotid cavernous fistula (type B) with drainage into the superior ophthalmic vein.

Figure 4. Axial treatment planning magnetic resonance imaging for gamma knife radiosurgery treatment showing the 50% prescription isodose line representing 18 Gy to the margin (yellow).
with poor vascular access and no fatal presentation, this may be a reasonable first-line treatment option.

Author contributions
Conceptualization: Eun-Jeong Koh.
Formal analysis: Kang Hoon Park.
Methodology: Jung Soo Park.
Writing – original draft: Kang Hoon Park, Jung Soo Park.
Writing – review & editing: Jung Soo Park, Eun-Jeong Koh, Jong-Myong Lee.

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