Percutaneous transluminal angioplasty in a patient with internal carotid artery stenosis following gamma knife radiosurgery for recurrent pituitary adenoma

Hidemichi Ito, Hidetaka Onodera, Taigen Sase, Masashi Uchida, Hiroyuki Morishima¹, Kotaro Oshio, Takashi Shuto², Yuichiro Tanaka

Departments of Neurosurgery, St. Marianna University School of Medicine, ¹Neurosurgery, Kawasaki Municipal Tama Hospital, ²Neurosurgery, Yokohama Rosai Hospital, Yokohama, Kanagawa, Japan

E-mail: *Hidemichi Ito - hdncito@yahoo.co.jp; Hidetaka Onodera - dera@marianna-u.ac.jp; Taigen Sase - sasetaigen@marianna-u.ac.jp; Masashi Uchida - m2uchida@marianna-u.ac.jp; Hiroyuki Morishima - h2mori@marianna-u.ac.jp; Kotaro Oshio - koshio@marianna-u.ac.jp; Takashi Shuto - shuto@yokohamah.rostefu.go.jp; Yuichiro Tanaka - tanaka@marianna-u.ac.jp
*Corresponding author

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INTRODUCTION

Gamma knife radiosurgery (GKS) has been considered as an effective and safe management strategy for recurrent pituitary adenoma.[5] A few side effects associated with this therapy have been described, such as pituitary insufficiency, visual dysfunction, dysfunction of the cranial nerves in the cavernous sinus, and vascular complication occasionally.[6] We report a case of symptomatic severe stenosis of the intracavernous segment of the internal carotid artery (ICA) 5 years after GKS. Percutaneous transluminal angioplasty (PTA) was performed successfully with anatomical and clinical improvement.

CASE REPORT

A 54-year-old male patient was admitted following a 3-month history of visual disturbance. He had no history of heart disease or metabolic disorder that could predispose to cerebrovascular complications. Neurological examination revealed a right homonymous hemianopia and decreased visual acuity. Magnetic resonance imaging (MRI) demonstrated a $5.0 \times 5.3$ cm pituitary tumor projecting toward the suprasellar region with encasement of both ICAs [Figure 1a]. The endocrinological findings were within the normal range. A transphenoidal surgery with subtotal removal
was achieved. The histological diagnosis was pituitary adenoma. Though the visual disturbance was temporarily improved after the operation, the residual tumor enlarged again in 1 year. The second transsphenoidal surgery was performed 3 years after the first operation. Preoperative magnetic resonance angiography (MRA) indicated that the cavernous segments of both ICAs were normal [Figure 1b]. Six months after the second surgery, the patient was treated with GKS for the residual tumor. The treatment was performed with a Leksell Gamma Knife model B (Elekta Instruments AB, Stockholm, Sweden). The tumor volume was 10.4 cm³. Dose planning was performed using MRI and computed tomography image fusion. The marginal dose to the tumor margin was 15 Gy at the 50% isodose curve [Figure 2a]. The irradiated dose of the cavernous segment of the right ICA was 20-22 Gy, retrospectively [Figure 2b].

Five years after the GKS, the MRA demonstrated severe stenosis of the cavernous segment of the right ICA with a remarkable reduction of the residual pituitary adenoma [Figure 3]. The following day, however, the patient had amaurosis. Diagnostic angiography revealed 95% stenosis of the cavernous ICA. With the progression of stenosis and being symptomatic, despite antiplatelet therapy, it was decided to proceed with ICA PTA. Initially 5000 U of heparin was administrated intravenously, activated clotting time was maintained at more than two times the control. A 7-Fr balloon guiding catheter (Optimo; Tokai Medical Products, Aichi, Japan) was emplaced selectively into the midcervical ICA. Next, a 0.014-inch regular microguidewire was navigated through the stenotic lesion into the supraclinoid segment of the ICA. Because the diameter of the normal part of cavernous segment of ICA was smaller (4.2-mm), a 2.5 × 9.0-mm Gateway Balloon Catheter (Boston Scientific Corporation, Natick, MA, USA) was advanced over the wire into the stenotic cavernous segment of the ICA. Careful low-pressure dilatations to a 2.5-mm diameter were performed under proximal flow control with inflation of the balloon guide catheter. Posttreatment angiography showed improvement in vessel diameter [Figure 4]. After the procedure, patient was managed through antiplatelet therapy for 3 months. Angiography 1 year after the PTA indicated slight restenosis of target lesion [Figure 5]; the patient remained asymptomatic.

**DISCUSSION**

Several therapeutic options are recommended for the management of pituitary adenomas, for example, medical treatment, surgery, or radiotherapy. Especially, in most cases of residual tumor or recurrence, radiotherapy has been used effectively. However, postoperative conventional radiotherapy has a high complication rate, including panhypopituitarism, visual disturbances, and cerebral stroke. Recently, GKS, among other types of radiosurgery, has gained wide acceptance as an effective and safe adjuvant postoperative treatment modality. Although few complications relative to conventional radiation therapy in the treatment of pituitary adenoma have been reported, it may induce modifications in the vessel walls after irradiation.

Accelerated atherosclerosis in the extracranial ICA is a well-recognized complication of irradiation for head and neck diseases. The rate of severe extracranial ICA has ranged from 6.3% to 16.0% in different series. Intracranial vascular complications following radiosurgery for pituitary adenomas and cerebrovascular accidents with intracranial artery occlusion after conventional radiation therapy have been reported in about 4.7-7.2%. In reviewing a series of patients receiving radiation therapy for pituitary adenoma, Hashimoto et al. reported 10 ischemic strokes in the long-term follow-up of 139 patients who received doses that varied between 50 and 60 Gy. Flickinger et al. reported 7 patients who suffered strokes due to intracranial arterial occlusion in 156 patients, and the occurrence of these strokes was delayed 3.2-14.6 years after irradiation. These authors reported an inability to find a clear correlation between ischemic strokes and radiation doses, fractions, and durations.

**DISCUSSION**

Intracranial vascular complications following radiosurgery seem to be extremely rare. The first case report of ICA stenosis after GKS was published by Ikeyama et al. They described multifocal stenosis in bilateral ICA, MCA, and ACA 6 months after GKS for an astrocytoma located at the left temporal lobe. Barami et al. summarized the vascular complications that occur after radiosurgery for meningiomas. Four cases with occlusive complications after GKS for cavernous sinus meningiomas were reported. Those reports indicated that the incidence of ICA occlusion or stenosis was 1.0-2.0% in a delayed fashion, usually 14-60 months after radiosurgery, and that the margin dose was 13-18 Gy, and the calculated radiation dose to the affected arteries was 25-36 Gy. Abeloos et al. also reported a case of ICA occlusion at 40 months after GKS for cavernous sinus meningioma. The prescribed margin dose was 13 Gy at the 50% isodose, and the estimated dose delivered to the cavernous ICA was 22.3 Gy. Only Lim et al. reported one patient, treated with GKS for a residual pituitary adenoma, who developed a cerebral infarction with cavernous ICA occlusion 4 years after GKS. The maximum dose was 40 Gy, and the dose to the right ICA was below 20 Gy. Cases with steno-occlusive complications to the ICA after GKS are summarized in the Table 1. Almost all patients had ischemic symptoms or suffered a stroke; therefore, there might also have been asymptomatic cases with stenotic arterial lesion.

Extracranial carotid artery angioplasty and stenting have clear advantages in treating patients with
radiation-induced extracranial carotid artery stenosis.[2,29] Even though intracranial PTA or stenting have been effective treatment options and more commonly performed in the setting of intracranial atherosclerotic disease, the efficacy and safety for radiation-induced arterial stenosis remains unknown.[5,26]

The restenosis rate of a stenting for symptomatic intracranial stenosis has been reported to be from 7.5% to 30%,[13,21,27] and that of a PTA was from 20.0% to 50.0%.[15,21,26] Though stenting may lower the rate of postoperative restenosis compared with PTA, Siddiq et al.[26] reported that no benefits of stenting over PTA in reducing stroke or death could be identified from their multicenter study. In the present case, only PTA was performed because the Japanese national insurance did not approve the use of intracranial stent devices for the first treatment. To avoid ischemic stroke, as part of follow-up, imaging should be closely performed to find restenosis. To our knowledge, this is the first reported case of PTA as an effective therapy for intracranial ICA stenosis due to radiotherapy. The present case suggests that arterial occlusion or stenosis could occur following GKS as delayed complications; therefore, the irradiation...
dose to the artery should be reduced as much as possible. Patients who undergo GKS for lesions involving major vessels should be monitored for arterial stenosis in the long-term follow-up even if the original disease is under control, and endovascular intervention including PTA and intracranial stenting may be of significant benefit to avoid ischemic stroke for these asymptomatic patients.

**CONCLUSION**

We reported a rare case of ICA stenosis 5 years after GKS for a recurrent pituitary adenoma. The irradiated vessels could be affected with stenosis in a delayed fashion; therefore, surveillance imaging should be performed even if the patient is asymptomatic up until that time. Endovascular angioplasty may most likely be the treatment of choice for steno-occlusive arteries following GKS.

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