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Case Report

Endovascular Stenting Following Stereotactic Radiosurgery for Meningioma Involving the Superior Sagittal Sinus

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Objective: Surgical removal of meningiomas that have partially invaded the superior sagittal sinus (SSS) is difficult because it requires reconstruction of the SSS, which can lead to SSS occlusion and venous infarction. The present report details the case of an SSS-involved meningioma treated by stereotactic radiosurgery (SRS) and stenting.

Case Presentation: A 60-year-old woman was admitted to the hospital with blurred vision and papilledema. Lumbar puncture showed markedly increased intracranial pressure (ICP; 340 mm H2O). Gadolinium-enhanced T1-weighted imaging revealed a 1-cm meningioma located mainly in the SSS. Digital subtraction angiography revealed severe stenosis, at the posterior part of the SSS, and no collateral flow. The ICP was considered a result of the stenosis caused by the meningioma. A combined therapy comprising transarterial embolization (for tumor growth suppression), endovascular stenting of the SSS (for intracranial hypertension improvement), and SRS (for tumor control) was planned. SRS was performed first to avoid interference by the metal artifacts caused by the stent. After placement of a self-expanding stent, partial recanalization was achieved. Two months after stenting, SSS stenosis improved and MRI results showed shrinkage of the meningioma. Thirty months after the treatment, no tumor recurrence was observed.

Conclusion: The treatment strategy of SRS followed by stenting was successful for a SSS-involved meningioma. ICP and a pressure gradient between the pre- and post-stenotic segments should be considered indications for stenting.

Keywords ▶ parasagittal meningioma, increased intracranial pressure, stereotactic radiosurgery, endovascular stenting

Introduction

Meningiomas involving the superior sagittal sinus (SSS) often cause venous congestion that leads to increased intracranial pressure (ICP).[1)] Surgical resection of such meningiomas requires reconstruction of the SSS, which carries risks of venous infarction or brain swelling.[1–4)] Some authors have reported success with endovascular stenting of the stenotic portion of the SSS combined with radiotherapy.[5–7)] However, the optimal timing of radiotherapy has not been reported.

The present case details a patient with a meningioma located mainly in the SSS and increased ICP. The patient was treated with stereotactic radiosurgery (SRS), transarterial embolization, and stenting. SRS was performed first out of consideration for the effect of metal artifacts caused by stenting. Endovascular stenting followed in order to treat SSS stenosis.

Case Report

A 60-year-old woman was admitted to the hospital with blurred vision lasting for 12 months and previously

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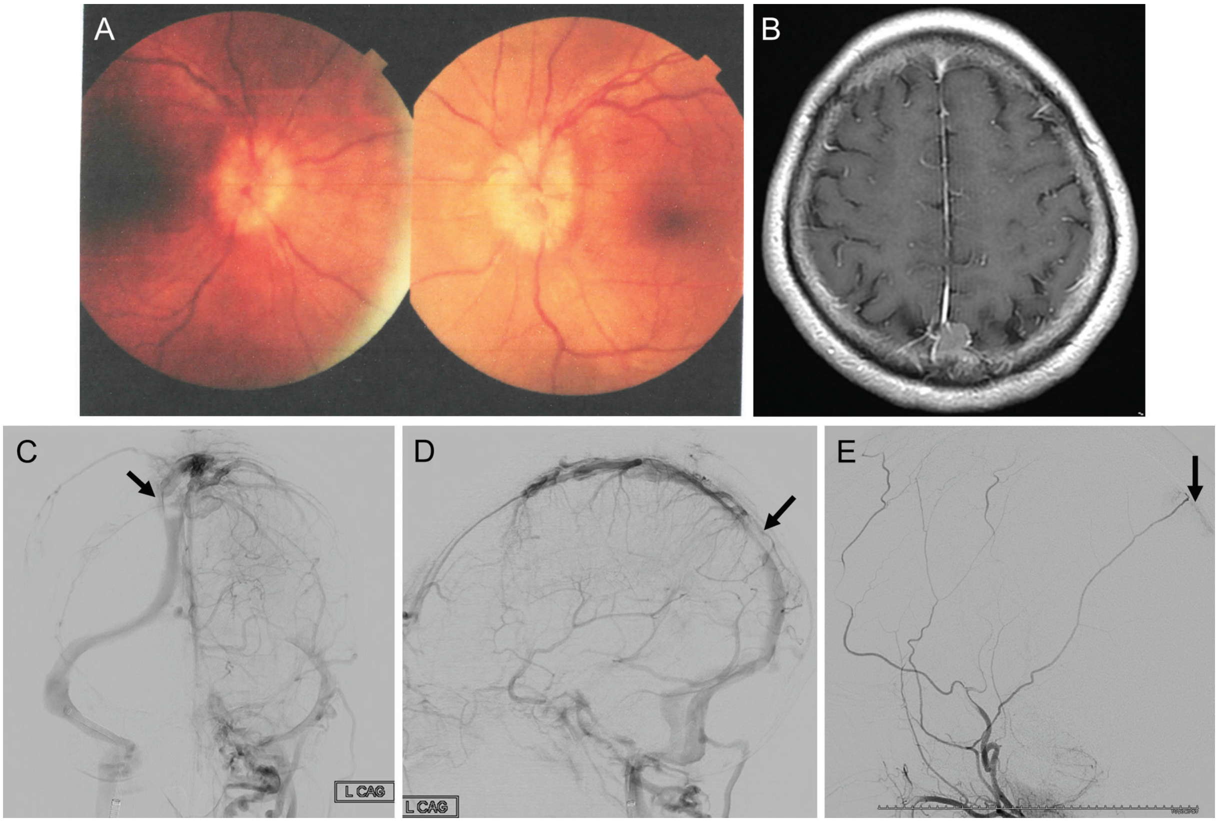

Fig. 1 (**A**) Preoperative fundoscopy showed bilateral papilledema, which suggested increasing intracranial pressure. (**B**) Axial views of gadolinium-enhanced T1-weighted images showing a tumor located mainly in the posterior third of the SSS. (**C–E**) Preoperative angiography: (**C**) Anterior–posterior views and (**D**) lateral views of the venous phase of left carotid angiography showing stenosis at the posterior third of the SSS (arrow), and no collateral flow from the anterior part of the SSS. (**E**) Left external carotid angiography showing a tumor stain from the posterior convexity branch of the middle meningeal artery (arrow). SSS: superior sagittal sinus

diagnosed bilateral papilledema (**Fig. 1A**). Visual acuity was 0.7 (1.2) on the right and 0.8 (1.2) on the left. Lumbar puncture revealed markedly elevated ICP up to 340 mm H2O. Gadolinium-enhanced T1-weighted MRI showed a mass lesion, 14 mm in size, at the posterior part of the SSS (**Fig. 1B**). Left carotid angiography revealed severe stenosis at the posterior third of the SSS with no collateral flow from the anterior and middle thirds (**Fig. 1C** and **1D**). The left external carotid artery showed a tumor stain (**Fig. 1E**). The diagnosis was a parasagittal meningioma located mainly at the posterior third of the SSS that increased the ICP via tumor-induced flow restriction. Early treatment was necessary because of the increased ICP. Surgical resection would require reconstruction of the SSS, which carries a risk of venous congestion and brain swelling. Therefore, a combined treatment of SRS and SSS stenting was planned. SRS was performed first to avoid complications caused by metal artifact from the stent.

Although stenting for SSS has not been approved in Japan, the treatment was approved by the institutional ethics review board. Written informed consent was obtained from the patient.

SRS was performed using the Novalis Tx system (Varian Medical Systems, Palo Alto, CA, and BrainLAB AG, Munich, Germany). The treatment plan was made with iPlan (Varian Medical Systems, Palo Alto, CA, and BrainLAB AG, Munich, Germany), using the fusion image of the CT and gadolinium-enhanced T1-weighted images. The gross tumor volume was 2.32 cm^3 and a 1-mm margin was set for planning the target volume. The central dose was 17 Gy and the marginal dose was 15.3 Gy.

Endovascular surgery for SSS stenting was performed under local anesthesia 5 days after SRS treatment. Prior to surgery, the patient was started on a regimen of aspirin (100 mg/day) and clopidogrel (75 mg/day) for 5 days. The activated clotting time was maintained between 250 and 300 seconds during the procedure via intravenous administration of heparin. A 4 French (4Fr) JB2 catheter (Medikit Co., Ltd, Tokyo, Japan) was advanced into the right internal carotid artery to visualize the veins. An 8Fr Shuttle guide sheath (Cook Medical Inc., Bloomington, IN, USA)

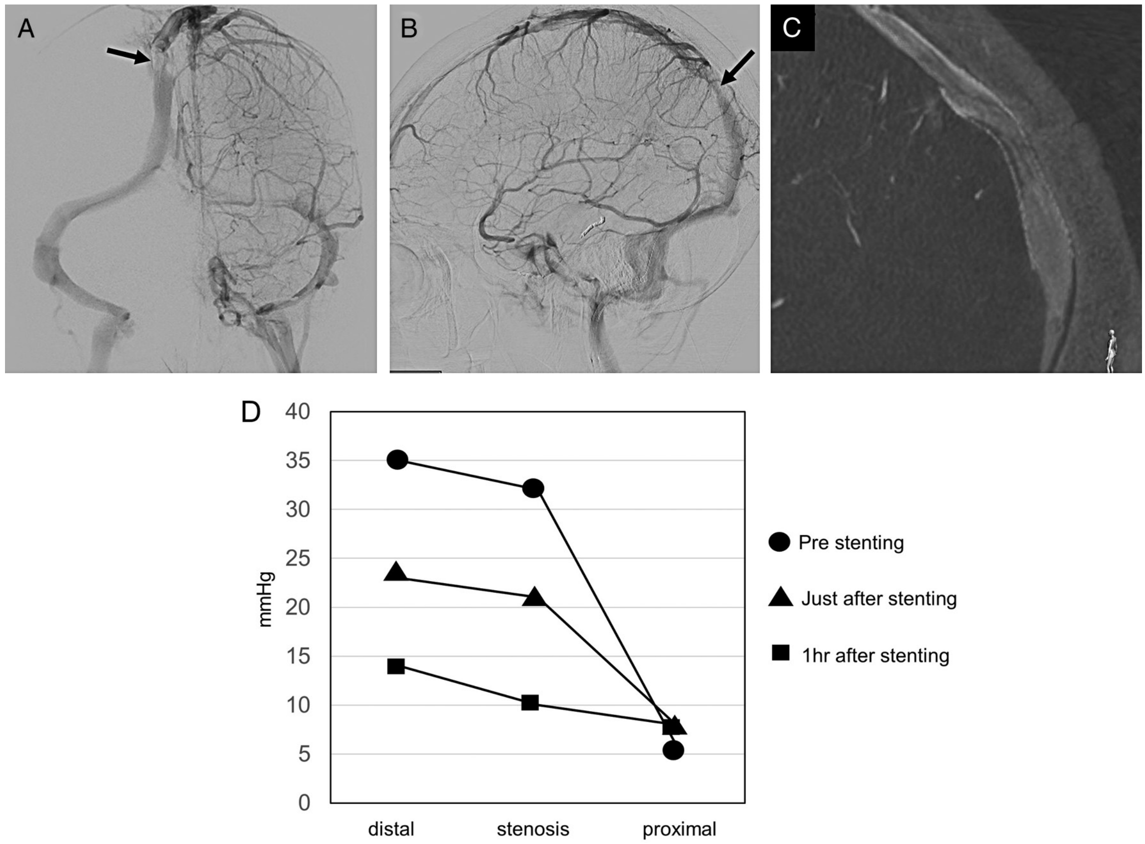

Fig. 2 (**A–C**) Postoperative angiography: (**A**) Anterior–posterior views and (**B**) lateral views of the venous phase of the left carotid angiography showing improvement in the degree of stenosis. (**C**) Reconstruction image of 3D digital subtraction angiography showing the stent along the stenosis. (**D**) Periprocedural change in venous pressure. Before stenting (circle), the venous pressure in the SSS distal to the stenosis increased remarkably. Immediately after stenting (square), the venous pressure distal to the stenosis decreased. However, the venous pressure distal to the stenosis was still higher than that in the proximal portion. One hour after stenting (triangle), the pressure gradient between the pre- and post-stenotic segments was improved. SSS: superior sagittal sinus

and an 8Fr FUBUKI guide catheter (Asahi Intecc Co., Ltd., Aichi, Japan) were advanced into the right sigmoid sinus and right transverse sinus, respectively. An SL-10 microcatheter (Stryker, Kalamazoo, MI, USA) was guided into the middle part of the SSS over a CHIKAI-14 200 cm guidewire (Asahi Intecc Co., Ltd., Aichi, Japan); wire exchange to a CHIKAI-14 300 cm guidewire was performed. Predilatation was performed using an Rx-Genity 4.0 mm × 30 mm balloon catheter (Kaneka Medix Corp., Osaka, Japan). When the balloon was inflated to 3 atm, the patient complained of headache and nausea; the balloon was then deflated.

A Precise Pro RX 8 mm × 40 mm stent (Cordis Corporation, Miami Lakes, FL, USA) was deployed across the stenotic segment of the SSS. Post-dilatation was performed using a 6.0 mm × 20 mm balloon catheter (Kaneka Medix Corp.). Following stenting, transarterial embolization of the middle meningeal artery was performed using 100–300 µm Embosphere microspheres (Nippon Kayaku Co., Ltd, Tokyo, Japan) and a coil. The final angiography showed partial recanalization of the SSS (**Fig. 2A–2C**). As shown in **Fig. 2D**, the pressure gradient immediately improved after stenting. Postoperatively, antiplatelet therapy with aspirin and clopidogrel was continued, and warfarin was started 1 day after surgery. The patient was discharged 7 days post-surgery with a modified Rankin Scale score of 0. Aspirin was discontinued 3 weeks post-surgery and clopidogrel was discontinued 6 months post-surgery. Two months after surgery, the anticoagulation therapy was changed from warfarin to edoxaban. Four months after stenting, ophthalmic examination showed visual acuity of 1.0 (1.2) on the right and 1.0 (1.5) on the left, and bilateral papilledema fully regressed (**Fig. 3D**). Fifteen months after stenting, complete recanalization was achieved (**Fig. 3A** and **3B**). Anticoagulant therapy was discontinued as flow restriction improved. No recurrence of the meningioma was observed at 30 months after treatment (**Fig. 3C**).

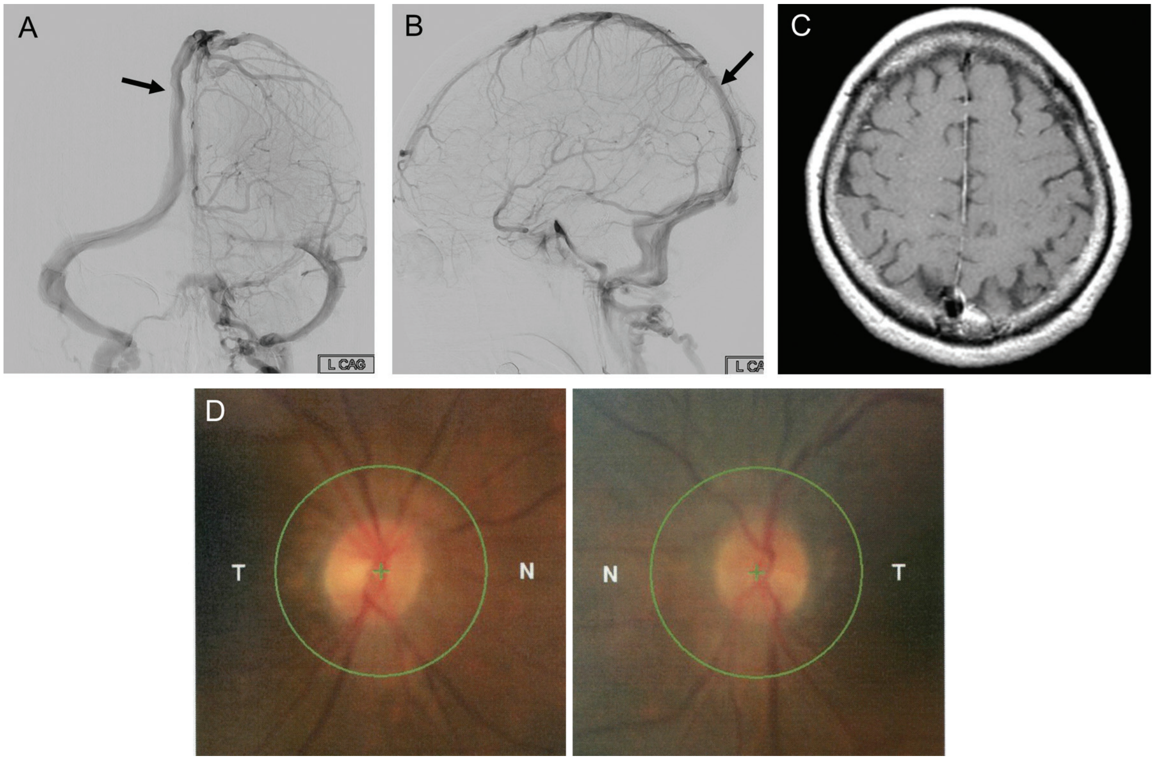

Fig. 3 Fifteen months after stenting, (**A**) anterior–posterior views and (**B**) lateral views of the venous phase of left carotid angiography showing improvement of the stenosis compared with that immediately after stenting. (**C**) Axial gadolinium-enhanced T1-weighted image showing shrinkage of the tumor. (**D**) Postoperative fundoscopy showed improvement in bilateral papilledema.

Discussion

In the present case, a patient was admitted with a meningioma located mainly in the SSS that was successfully treated by a combination of SRS and endovascular stenting.

Meningiomas that partially involve the venous sinus sometimes cause increased ICP because of poor collateral supply. DiMeco et al. reported that 2.7% of these meningiomas presented with increased ICP.[1)] The reported surgical complications of meningiomas involving the SSS include venous infarction in 8% of cases, hemorrhagic complication in 1.85%, and paresis in 3%. Therefore, surgical treatment for these meningiomas has a moderate risk.[1–3)] A systematic review by Giordan et al. showed a 4% incidence of venous infarction when surgical removal and venous reconstruction were performed.[4)] In the present case, the tumor was located mainly in the SSS, and only the dural thickness was shown at the intradural portion. Digital angiography showed severe stenosis of the posterior third of the SSS and no collateral supply from the anterior and middle thirds of the SSS. Sinus reconstruction was required and venous infarction after surgery was predicted.

SRS treatment for parasagittal meningiomas has also been reported in previous studies. Kondziolka et al. reported 66 cases of parasagittal meningiomas treated by SRS with a tumor control rate of 93%.[8)] Pamir et al. reported 43 cases of SSS-involved meningiomas treated by SRS with a tumor control rate of 89% at 46 months.[9)] New peritumoral edema or pre-existing edema has been shown to worsen in 40% of treated meningiomas.[10)] Edema has been shown to occur 6 months after SRS treatment.[10)] In the present study, endovascular stenting was performed 5 days after SRS. Thus, the risk of obstruction of the SSS due to edema was thought to be low. These reports suggest that SRS is an effective treatment for parasagittal meningiomas.

Only five studies have previously reported cases of stenting of SSS-involved meningiomas to improve venous congestion (**Table 1**).[5–7,11,12)] In all five cases, there was papilledema, suggesting increased ICP. Stenting improved papilledema in all five cases and sinus patency was confirmed at the last follow-up. In three of the five cases, stenting was combined with radiotherapy. SRS was performed in only one case, followed by stenting. Although in four of the five cases, a balloon-mounted

Table 1 Reported case of stenting for meningioma invading the sinus

Author	Age/sex	Symptom	Location	Affected sinus	Treatment	Antithrombotic therapy	Radiotherapy
Ganesan[5]	45/M	Headache burr vision	Parasagittal	SSS	Balloon expandable size n.a.	WF → ASA	Post-stenting 55 Gy/33 Fr
Higgins[6]	46/M	Headache burr vision	Tentorial	Confluence	Balloon expandable 6 mm x 38 mm	WF → ASA	Pre-stenting 55 Gy/33 Fr
Zilani[7]	54/F	Hearing loss tittinus ataxia	Petrous	IJV	Balloon expandable 6 mm x 24 mm	ASA, CLP	Post-stenting γ knife detail n.a.
Chausson[10]	55/F	Incidental	Meningomatosis	TS	Self-expanding 8 mm x 40 mm	CLP	(–)
Entezami[11]	56/M	Headache burr vision	Parasagittal	SSS	Self-expanding close cell 8 mm x 21 mm	ASA	(–)
Present case	60/F	Headache burr vision	Parasagittal	SSS	Self-expanding open cell 8 mm x 40 mm	ASA, CLP WF to edoxaban	Pre-stenting X knife 17Gy

ASA: aspirin; CLP: clopidogrel; F: female; IJV: internal jugular vein; M: male; n.a: not available; SSS: superior sagittal sinus; TS: transverse sinus; WF: warfarin

stent was used, the present case involved a self-expanding stent due to expectations of long-term expansion by radial force. Specifically, an open-cell stent was used because it has a greater radial force than that of closed-cell stents, which are not approved for treatment of SSS in Japan. In the present case, headache and nausea were caused by balloon angioplasty that did not reach nominal pressure, which was determined to be a result of inadequate dilatation of the SSS. As a result, a carotid stent was used and partial recanalization was achieved immediately after stenting; complete recanalization was achieved 2 months after stenting. Kumpe et al.[13] reported a case series of idiopathic intracranial hypertension treated with similar stenting. They reported patency of all stents without in-stent stenosis at follow-up after 25.4 months. Additionally, in the present case, headache and nausea occurred during pre-stent angioplasty. Thus, the use of a balloon-expandable stent would have been difficult. The use of a self-expandable stent was the efficient choice in the present case.

The optimal indications for stenting in cases of meningioma have not been reported. Teleb et al.[14] proposed indications for stenting in cases of idiopathic ICP increase, which is often associated with SSS stenosis. They proposed the following indications: refractoriness to medical treatment, worsening visual symptoms, and a pressure gradient >8 mm Hg between the pre- and post-stenotic segments. In the present case, papilledema was observed, indicating increased ICP, and a pressure gradient between the pre- and post-stenotic segments was present. Thus, stenting was applicable.

Regarding the use of antithrombotic therapy among the previously reported five cases, patients in two cases were started on warfarin immediately after stenting for a period of 2 months. They were subsequently switched to aspirin. In three cases, patients received antiplatelet therapy before stenting. No periprocedural or postoperative ischemic or hemorrhagic complications were reported. In the case of an increase in idiopathic ICP, the use of antithrombotic therapy with stenting has been controversial.[14–16] In the present case, aspirin and clopidogrel were used to prevent the formation of a white clot, which is caused by shear stress. After stenting, partial recanalization was obtained and warfarin was used to prevent the formation of a red clot, which is caused by venous congestion. Antiplatelet and anticoagulant agents were discontinued when endothelialization and complete recanalization were achieved.

Conclusion

The treatment strategy of SRS followed by stenting was useful for a meningioma that involved the SSS. Increased ICP and a pressure gradient between the pre- and post-stenotic segments were considered indications for stenting. Combined therapy with antiplatelet and anticoagulant agents was useful to prevent ischemic complications.

Disclosure Statement

We declare no conflicts of interest.

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