

Low-Dose Gamma Knife Radiosurgery for Cavernous Sinus Hemangioma: Report of 3 Cases and Literature Review

Authors

P. Ivanov^{1,5}, M. Chernov³, M. Hayashi^{1,2,4}, K. Nakaya¹, M. Izawa¹, N. Murata¹, O. Kubo¹, H. Ujije¹, Y. Muragaki^{1,2}, R. Nakamura^{2,3}, H. Iseki^{1,2,3}, T. Hori¹, K. Takakura^{1,2,3}

Affiliations

Affiliation addresses are listed at the end of the article

Key words

- cavernous sinus hemangioma
- treatment
- gamma knife radiosurgery

Abstract

Optimal management of cavernous sinus hemangiomas remains unclear. Total microsurgical removal of these neoplasms may be extremely difficult due to their rich vascularization. Three cases of cavernous sinus hemangioma treated with low-dose Gamma Knife radiosurgery are presented. Marginal dose varied from 10 to 13 Gy. Treatment planning and radiation dosimetry were done with a goal of conformal and selective coverage of the lesion with 50% prescription isodose line using multiisocenter technique. In

all cases significant shrinkage of the neoplasm was marked at 3 months after treatment. Mean volume reduction at 12 months after radiosurgery was 60% (range: 45–75%). In all patients the shrinkage of the neoplasm was accompanied by notable improvement of the preexistent oculomotor nerve palsy. No radiosurgery-related complications were met during follow-up. In conclusion, low-dose Gamma Knife radiosurgery seems to be very effective for management of cavernous sinus hemangiomas, and can be considered as a treatment modality of choice for these lesions.

Introduction

Cavernous sinus hemangiomas constitute less than 1% of all parasellar mass lesions [1]. The optimal strategy of their management is still a matter of some controversy [2]. The frequent involvement of the lateral wall of the cavernous sinus may require microsurgical resection of the lesion directed for the decompression of the cranial nerves. Total removal of the neoplasm, however, may be extremely difficult due to its rich vascularization, which frequently results in excessive intraoperative bleeding [3–5]. Incomplete microsurgical removal necessitates adjuvant treatment with either fractionated radiotherapy or stereotactic radiosurgery [6,7]. Herein we report the outcome in 3 patients with cavernous sinus hemangiomas treated with low-dose gamma knife radiosurgery, and present an analysis of the reported data considering the diagnostic nuances and results of radiosurgical management of these rare lesions.

Tokyo Women's Medical University. Three of them (0.001%) had cavernous sinus hemangioma. Summaries of the treatment and outcome characteristics in these cases are presented below.

In all 3 patients a Leksell Gamma Knife model C with automatic positioning system (Elekta Instruments, Stockholm, Sweden) was used. Visualization of the lesion within the cavernous sinus at the time of radiosurgery was attained with MRI using axial 1.0-mm slices of modified Time-of-Flight and Field Echo images with and without gadolinium enhancement, as well as coronal 2.0-mm slices of T₂-weighted images. Axial 1.0-mm slices of the “bone window” and contrast-enhanced brain CT were additionally used, mainly for control of distortion artifacts on MR images. All data were transferred into the Leksell GammaPlan (Elekta Instruments, Stockholm, Sweden) through the local network. Treatment planning and radiation dosimetry were done with a goal of conformal and selective coverage of the lesion with a 50% prescription isodose line using the multiisocenter technique (● Fig. 1). Low-dose radiosurgery was used in all cases; the mean marginal dose constituted 11.7 Gy (range: 10–13 Gy). Special attention was given to avoid

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DOI 10.1055/s-2008-1065346
 Minim Invas Neurosurg 2008;
 51: 140–146
 © Georg Thieme Verlag KG
 Stuttgart · New York
 ISSN 0946-7211

Correspondence

M. Hayashi, MD, PhD
 Department of Neurosurgery
 Neurological Institute
 Tokyo Women's Medical
 University
 8-1 Kawada-cho
 Shinjuku-ku
 Tokyo 162-8666
 Japan
 Tel.: +81/3/3353/81 11
 (ext. 26216)
 Fax: +81/3/5269/74 38
 GKRmoto@aol.com

Patients and Methods

From January 1, 2002 to December 31, 2006, 2043 patients underwent gamma knife radiosurgery in

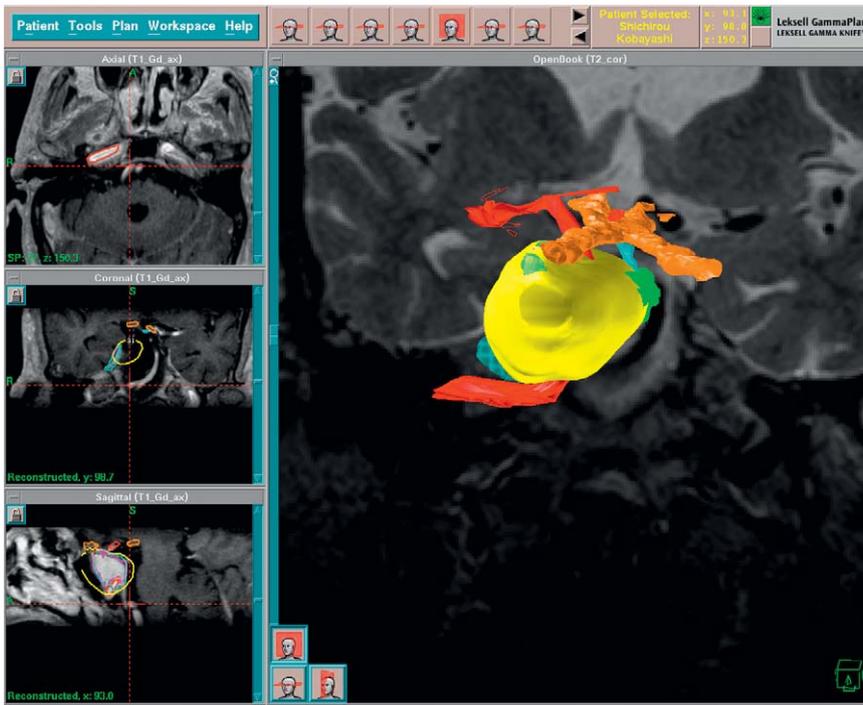


Fig. 1 Radiosurgical treatment plan for cavernous sinus hemangioma: the target is completely covered with 50% prescription isodose (yellow), but optic pathways (brown), carotid artery bifurcation (red), pituitary gland (green), and pituitary stalk (blue) are kept outside of the irradiated area.

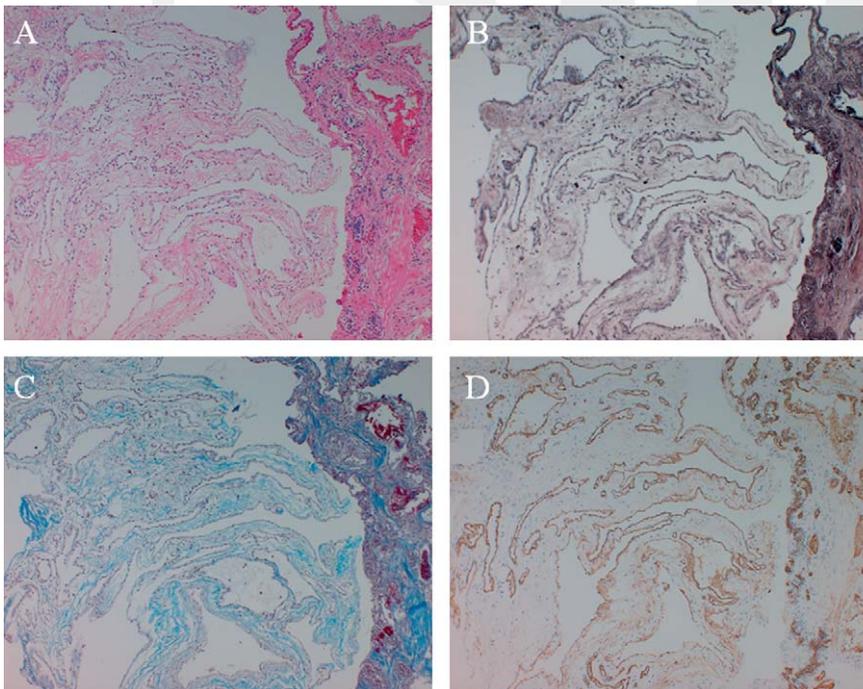


Fig. 2 Histological specimen of the cavernous sinus hemangioma (A: H&E; B: reticulin stain; C: Masson stain; D: CD34 immunohistochemical stain; $\times 200$). Note presence of multiple wide vascular channels, lined with a single layer of endothelial cells.

incorporation of the lateral wall of the cavernous sinus into the 80% isodose area. The irradiation dose for the optic pathways was kept below 8 Gy. Various treatment parameters were calculated routinely using Leksell GammaPlan software. All patients were scheduled for regular clinical and radiological follow-up every 3 months during the first post-treatment year, every 6 months during the second post-treatment year, and once per year thereafter.

Patient 1

A 53-year-old woman presented with double vision due to left oculomotor and abducens nerve palsy. CT and MRI disclosed a large well-demarcated rounded mass lesion of the left cavernous sinus with extension into the middle cranial fossa and com-

pression of the temporal lobe. The neoplasm gave an isointense signal on T₁-weighted images, a markedly hyperintense signal on T₂-weighted images, and showed prominent homogeneous contrast enhancement. The diagnosis of a cavernous sinus meningioma was established and its elective microsurgical resection was attempted. An encapsulated, reddish, highly vascular neoplasm within the cavernous sinus was identified at surgery. Excessive bleeding constantly accompanied tumor removal, therefore only partial resection was attained. Histopathological examination revealed a cavernous sinus hemangioma (● Fig. 2). Three months later radiosurgery of the residual neoplasm was done (● Fig. 3). The target volume constituted 19 mL. The treatment parameters were as follows: marginal dose corresponding to 50% isodose line, 10 Gy; conformity index, 0.99; selectivity

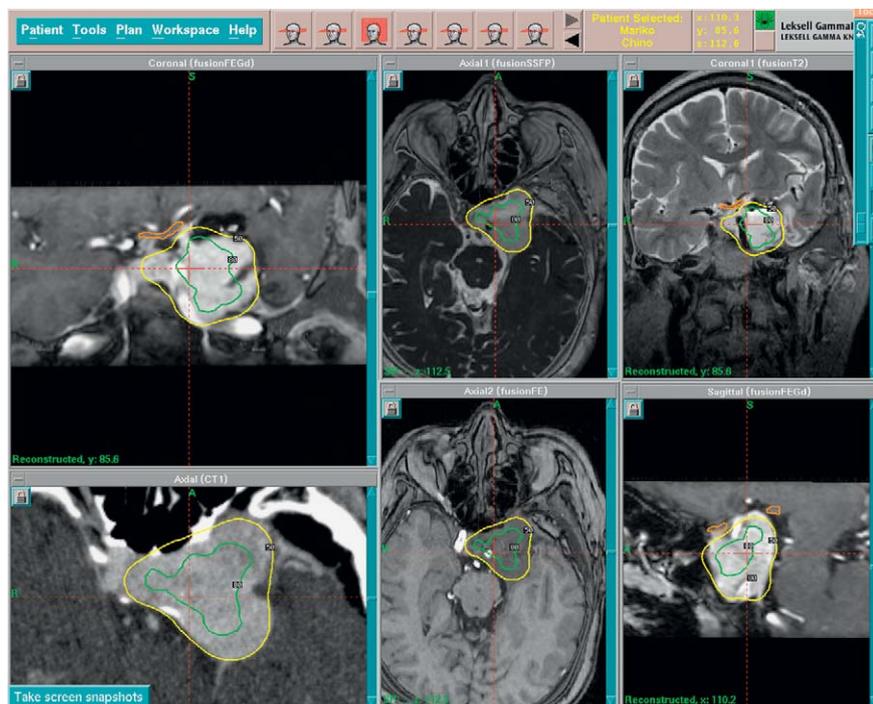


Fig. 3 Radiosurgical treatment plan for cavernous sinus hemangioma in Patient 1. Note, that the lateral wall of the cavernous sinus is kept outside of the 80% isodose (green), and presence of a distance between optic pathways (brown) and 50% prescription isodose line (yellow).

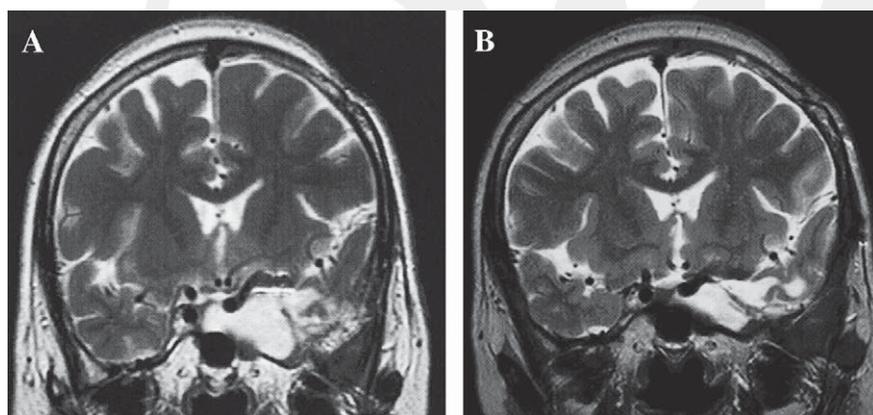


Fig. 4 Coronal T₂-weighted MRI of the Patient 1 during follow-up. Volume reduction of the neoplasm at 3 (A) and 12 (B) months after radiosurgery constituted 40% and 60%, respectively.

index, 0.89; unit energy delivered to the lesion, 14.5 mJ/mL. No complications or side effects were met. Three months after radiosurgery a 40% volume reduction of the lesion was marked, which was accompanied by gradual improvement of the left oculomotor nerve palsy. The abducens nerve palsy remained stable. At 12 months after treatment a 60% shrinkage of the neoplasm was marked (● Fig. 4).

Patient 2

A 38-year-old woman underwent partial removal of a right cavernous sinus hemangioma in another hospital. Eight months later she was admitted for management of the residual neoplasm. Neurological examination at that time revealed right oculomotor nerve palsy. MRI showed the typical characteristics of a cavernous sinus hemangioma with extension into the middle cranial fossa, and radiosurgery was performed (● Fig. 5). The target volume constituted 12.7 mL. The treatment parameters were as follows: marginal dose corresponding to 50% isodose line, 12 Gy; conformity index, 0.96; selectivity index, 0.76; unit energy delivered to the lesion, 16.3 mJ/mL. No complications or side effects were met. Volume reduction at 3 and 12 months after radiosurgery constituted 50% and 75% respec-

tively (● Fig. 6) and was accompanied by progressive improvement of the right oculomotor nerve palsy.

Patient 3

A 67-year-old man presented with diplopia on right-side and upward gaze. Neurological examination revealed right oculomotor nerve palsy. MRI disclosed a mass lesion of the right cavernous sinus with extension into the middle cranial fossa. The neoplasm gave an isointense signal on T₁-weighted images, a markedly hyperintense signal on T₂-weighted images, and showed prominent homogeneous contrast enhancement. Based on the neuroradiological characteristics the diagnosis of a cavernous sinus hemangioma was established and radiosurgical treatment was done (● Fig. 7). The target volume constituted 6.4 mL. The treatment parameters were as follows: marginal dose corresponding to 50% isodose line, 13 Gy; conformity index, 0.98; selectivity index, 0.67; unit energy delivered to the lesion, 18.5 mJ/mL. No complications or side effects were met. Volume reductions at 3 and 12 months after radiosurgery constituted 30% and 45%, respectively (● Fig. 8), and were accompanied by progressive improvement of the right oculomotor nerve palsy. During further 4 years of follow-up the size of the lesion

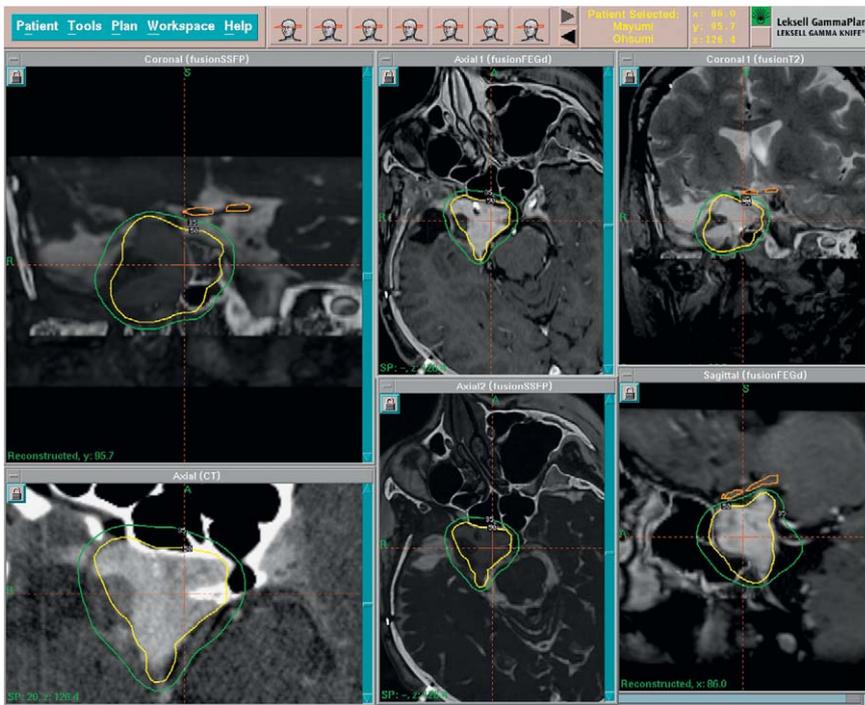


Fig. 5 Radiosurgical treatment plan for cavernous sinus hemangioma in Patient 2. Note a distance between optic pathways (brown) and 35% isodose line (green), corresponding to 8.4 Gy irradiation dose.

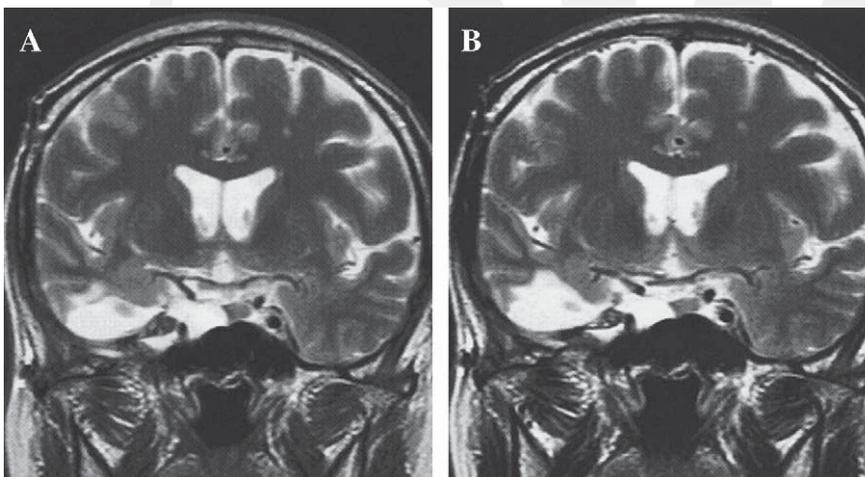


Fig. 6 Coronal T₂-weighted MRI of the Patient 2 during follow-up. Volume reduction of the neoplasm at 3 (A) and 12 (B) months after radiosurgery constituted 50% and 75%, respectively.

remained stable, whereas extraocular movements of the right eyeball recovered completely.

Discussion

Various terms had been previously used for the naming of cavernous sinus hemangioma, such as cavernoma, cavernous malformation, or extracerebral cavernous angioma [8–10]. The detailed histopathological characterization of these neoplasms remained obscure due to their rarity [2]. Microscopically, the lesion is characterized by the presence of wide vascular channels, lined with a single layer of endothelial cells without an elastic membrane [1, 11–16]. In spite of the vascular nature of the cavernous sinus hemangioma, hemorrhages are extremely unusual during the natural course of the disease [2, 11, 17]. Lesion growth is typically accompanied by a mass effect and can result in encasement of the adjacent neurovascular structures [10, 12, 18]. Therefore, these lesions are considered both as vascular malformations [2, 10, 14] and vascular tumors [4, 8, 13, 17].

Nevertheless, the necessity to separate this entity from parenchymal brain cavernomas has become evident recently, due to completely different clinical courses and responses to therapy [2].

Linskey et al. [19] reviewed 53 cases of cavernous sinus hemangiomas reported between 1943 and 1991. A non-exhaustive literature search permitted us to identify 73 additional cases, published during the last 15 years [1–5, 7, 9–18, 20–22]. Analysis of these reports did not permit us to identify any specific clinical or radiological feature, which can potentially be used for precise identification of the neoplasm and its differential diagnosis with other lesions of the same location.

Cavernous sinus hemangiomas are usually diagnosed in middle-aged women [9, 10, 15, 17, 20]. Typical tumor-like biological behavior is reflected in the gradual progression of the neurological symptoms and signs caused by compression of the adjacent neurovascular structures [2, 3, 11, 13–15, 20, 22]. On CT the neoplasm is usually seen as a well-defined isodense or slightly hyperdense mass lesion with marked homogeneous contrast enhancement [1, 5, 11, 13]. Destruction of the adjacent bony

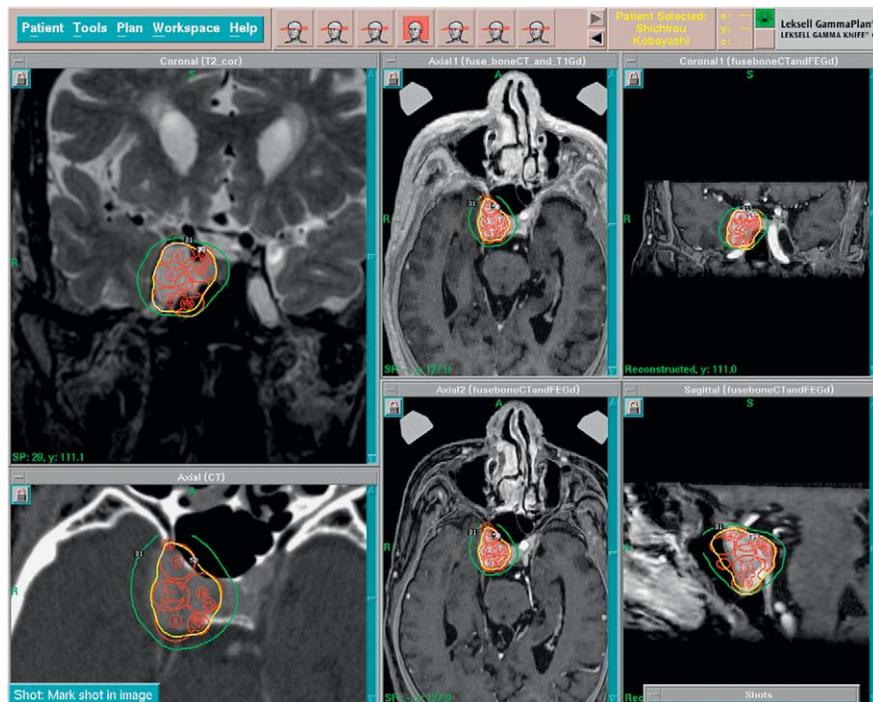


Fig. 7 Radiosurgical treatment plan for cavernous sinus hemangioma in Patient 3. Note selective positioning of isocenters (red circles) within 50% prescription isodose line (yellow).

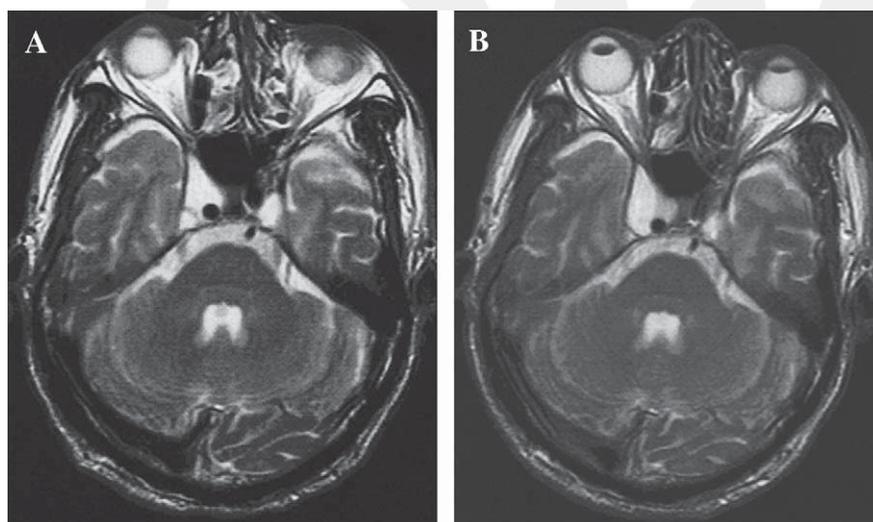


Fig. 8 Axial T₂-weighted MRI of the Patient 3 during follow-up. Volume reduction of the neoplasm at 3 (A) and 12 (B) months after radiosurgery constituted 30% and 45%, respectively.

structures can be identified, whereas calcifications are rare [1, 10, 12, 19]. On cerebral angiography the lesion may be either avascular or show vascular blush. In such cases Yao et al. [22] consistently found displacement of the intracavernous internal carotid artery. Nevertheless, there are no specific angiographic signs of cavernous sinus hemangioma [9, 10, 12, 17, 18, 23]. Scintigraphy was proposed for diagnosis of the neoplasm [1], but did not attain wide acceptance.

MRI is the method of choice for the diagnosis of cavernous sinus hemangiomas. Similar to extracranial hemangiomas iso- to hypointensity on T₁-weighted images and marked signal hyperintensity on T₂-weighted images represent the most typical features of the neoplasm [1, 11, 13, 15, 17, 19, 22, 23]. The structure of the lesion can be either homogeneous [10, 20, 22], or heterogeneous [3, 16], but in contrast to parenchymal brain cavernomas, a hemosiderin rim and other areas of decreased signal intensity, corresponding to the hemosiderin deposits, are absent [1, 10]. Nevertheless, other parasellar tumors, namely chordomas, lymphomas, metastases, and some histological subtypes of

meningiomas, may exhibit markedly increased signal intensity on T₂-weighted MRI [3, 12, 14]. Figueiredo et al. [23] reported a rare case of angioleiomyoma of the cavernous sinus, the MRI characteristics of which were indistinguishable from those of hemangioma. Post-gadolinium T₁-weighted images can be used for differential diagnosis in such cases, and it was suggested that strong homogeneous enhancement is typical for tumors, whereas cavernous sinus hemangiomas usually have patchy or heterogeneous contrast enhancement [3, 5, 9, 10, 14, 18, 22]. The pattern of contrast enhancement of the cavernous sinus neoplasms on post-gadolinium T₁-weighted MRI may, however, vary widely. At least 2 out of 3 lesions presented herein exhibited prominent homogeneous contrast enhancement. Therefore, it can be concluded that, in general, MRI characteristics do not have enough specificity for the precise diagnosis of cavernous sinus hemangiomas.

Non-specific clinical and radiological features of the neoplasm may necessitate its open biopsy [12]. In 69 out of 73 previously reported cases, which were reviewed by us, the histopathologi-

cal confirmation of the diagnosis was done. Two out of 3 presented patients underwent initial partial resection of the lesion. Beside tissue sampling, the main indication for surgery in cases of cavernous sinus hemangiomas is decompression of the neurovascular structures within or in the vicinity of the cavernous sinus. Complete excision of the lesion may be, however, extremely difficult because of its rich vascularization. Excessive intraoperative hemorrhage is not uncommon in such cases and may result in the necessity to interrupt the surgical procedure before achievement of the total lesion resection [3–5, 15, 21]. Stereotactic radiosurgery or fractionated radiotherapy had been used for management of cavernous sinus hemangiomas and a significant body of evidence suggests that these lesions are highly radiosensitive [6, 7]. In the majority of cases, as well as in our own presented herein, significant shrinkage of the neoplasm can be marked as early as 3 months after treatment [13, 17, 20]. Previously reported mean rates of the volume reduction after radiosurgery for cavernous sinus hemangiomas vary from 43% to 68% [13, 17, 20], and correspond well to the 60% mean volume reduction found at 12 months after radiosurgery in our cases. Therefore, Thompson et al. [13] concluded that an intracavernous mass lesion with imaging characteristics consistent with hemangioma should undergo radiosurgical treatment. Nevertheless, radiosurgery is frequently considered suitable only for non-operable cavernous sinus hemangiomas or for residual neoplasm after initial attempts of microsurgical resection [3–5, 13, 17].

There is a common opinion that, in cases of cavernous sinus hemangioma, radiosurgery can aggravate cranial nerve palsy. But, in fact, we were not able to identify any reported neurological complication, including radiation-induced neuropathy, after radiosurgery of these lesions. Radiosurgery-related complications were not met during a follow-up of sufficient length in any case presented herein. Moreover, in all our patients the shrinkage of the neoplasm was accompanied by a significant improvement of the oculomotor nerve palsy. Such a favorable outcome definitely resulted from conformal and selective dose planning, with sparing of the lateral wall of the cavernous sinus from involvement into the 80% isodose area. In agreement with Nakamura et al. [20], who suggested that lower radiosurgical doses are required for cavernous sinus hemangiomas compared to other benign tumors, we utilized low-dose radiosurgery, using on average an 11.7Gy marginal dose at the 50% prescription isodose line. The outcome in our cases confirmed the safety and effectiveness of such a treatment strategy.

In conclusion, low-dose gamma knife radiosurgery is very effective for the management of cavernous sinus hemangiomas. Significant volume reductions can be attained within several months after treatment, and are usually accompanied by improvement of the neurological signs. Optimal visualization of the lesion and surrounding structures, highly selective treatment planning, and the use of low marginal doses, permit us to avoid radiation injury to the adjacent neurovascular structures and minimize the risk of complications. Bearing in mind the significant difficulties which are usually encountered during microsurgical resection of the cavernous sinus hemangiomas, radiosurgery can be considered as a preferable treatment modality of choice for these lesions.

Acknowledgements



This work was supported by the Program for Promoting the Establishment of Strategic Research Centers, Special Coordination Funds for Promoting Science and Technology, Ministry of Education, Culture, Sports, Science and Technology (Japan). The authors are thankful to Mr. Takashi Yamamoto for invaluable help with preparation of the manuscript.

Affiliations

¹ Department of Neurosurgery, Neurological Institute, Tokyo Women's Medical University, Tokyo, Japan

² Faculty of Advanced Techno-Surgery, Institute of Advanced Biomedical Engineering and Science, Tokyo Women's Medical University, Tokyo, Japan

³ International Research and Educational Institute for Integrated Medical Sciences (IREIIMS), Tokyo Women's Medical University, Tokyo, Japan

⁴ Saitama Gamma Knife Center, Sanai Hospital, Saitama, Japan

⁵ Radiosurgical Center, International Institute of the Biological Systems, St. Petersburg, Russia

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