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Surgical treatment of cavernous sinus meningioma with petrous bone invasion causing internal auditory canal stenosis and hearing impairment 7 years after gamma-knife radiosurgery

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Abstract

Background Surgical intervention for cavernous sinus meningiomas remains challenging because of their anatomically complicated location. We report a case of a cavernous sinus meningioma that enlarged and caused hearing impairment due to internal auditory canal stenosis 7 years after gamma-knife radiosurgery.

Case description A 38-year-old man with abducent nerve paralysis and dysesthesia on the left side of the face was diagnosed with a cavernous sinus meningioma with thickened petrous bone. After a year, the patient had mild left-sided hearing impairment, and gamma-knife radiosurgery was performed. At the age of 46, the left hearing impairment worsened, the tumor was slightly enlarged, and petrous bone thickening in the internal auditory meatus had progressed. We partially resected the tumor, which seemed to be viable, and removed the thickened petrosal bone and opened the internal auditory meatus. The tumor was pathologically diagnosed as meningothelial meningioma. The patient's hearing impairment did not progress, and the residual tumor had not grown for four years.

Conclusions Removal of the viable tumor that progressed after gamma-knife radiosurgery and opening of the internal auditory meatus were effective in stopping the worsening of hearing impairment and controlling the tumor.

Keywords Cavernous sinus meningioma, Gamma-knife radiosurgery, Meningothelial meningioma, Hearing impairment

Background

Complete removal of cavernous sinus meningiomas is usually difficult because they appear in anatomically complicated locations. The cavernous sinus contains important structures such as the internal carotid artery and cranial nerve (CN), which make gross total resection challenging. Alternatively, gamma-knife radiosurgery (GKRS) is an effective treatment option for cavernous sinus meningioma. However, not all cavernous sinus meningiomas can be controlled by GKRS alone. We report a case of a cavernous sinus meningioma that enlarged and caused hearing impairment due to internal auditory canal stenosis.

Case description

A man presented with left abducent nerve paralysis at the age of 36. At the age of 38 years, the patient had dysesthesia on the left side of the face and was diagnosed with

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a cavernous sinus meningioma with a thickened petrous bone. Magnetic resonance imaging (MRI) revealed a well-circumscribed and gadolinium-enhanced lesion extending from the left clivus to the left petrous apex. The tumor invaded the left cavernous sinus and the prepontine cistern and contacted the surface of the pons. Computed tomography (CT) revealed petrous bone thickening (Fig. 1). Subsequently, the tumor size did not change, and watchful waiting continued.

At the age of 39 years, the patient had mild left-sided hearing impairment and tinnitus. On audiometry, the mean pure tone average (PTA) in the left ear was 27 dB. GKRS was performed because the tumor was small and hearing impairment had gradually progressed. The median margin dose was 12 Gy, and the median central dose was 20 Gy (Fig. 2). Although mild abducent nerve paralysis persisted, his tinnitus disappeared. MRI was performed every six months for four years after GKRS, and the tumor size did not change.

At the age of 46 years, the left-sided hearing impairment suddenly worsened. In an audiogram, the PTA in the left ear increased to 92.5 dB from 54 dB over a period of three months. MRI revealed that the tumor enlarged slightly toward the posterior fossa, and CT showed petrous bone thickening that led to stenosis of the internal auditory meatus (Fig. 3). This suggested that his hearing impairment was caused by stenosis of the internal auditory meatus due to thickening of the petrous bone. The patient underwent tumor removal to stop worsening of his hearing impairment and to make a definitive diagnosis. The thickened petrosal bone was resected, and the internal auditory meatus was opened widely using the left anterior transpetrosal approach. The posterior part of the tumor was soft and seemed to be viable. In contrast, the anterior part was hard, which might have been affected by GKRS and seemed not to be viable. The posterior part was removed, and the anterior part was left to avoid abducens nerve damage (Fig. 4). The tumor was pathologically diagnosed as a meningothelial meningioma (World Health Organization grade I), which had invaded the petrous bone. After surgery, the size of the residual tumor did not change, and the patient's left-sided hearing impairment did not worsen for four years.

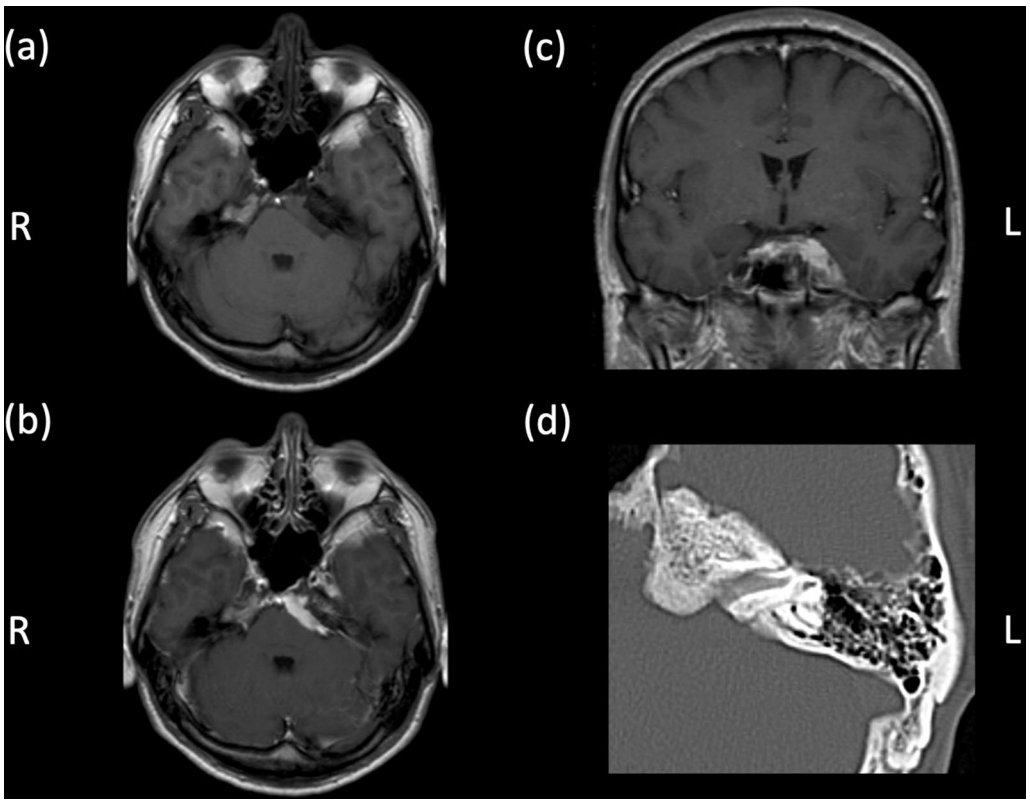

Fig. 1 Preoperative images of the cavernous sinus tumor. **a** Axial view of T1-weighted image on brain MRI. **b** Axial view of gadolinium-enhanced T1-weighted brain MRI demonstrating a well-enhanced tumor and enhanced petrous bone. **c** Coronal view of the gadolinium-enhanced T1-weighted MRI. **d** Axial image of CT demonstrates petrous bone thickening and stenosis of internal auditory canal

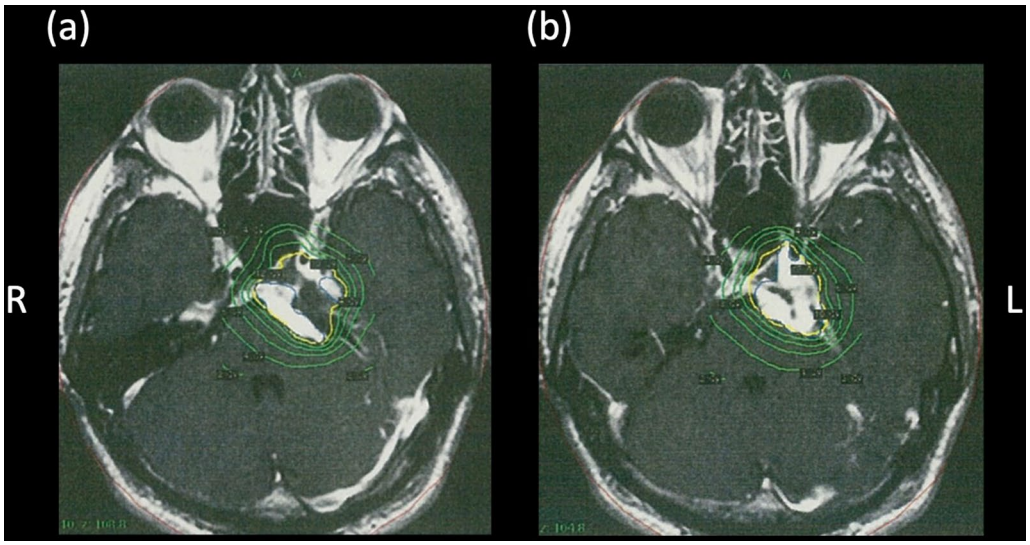

Fig. 2 **a**, **b**: Gamma-knife radiosurgery plans for the cavernous sinus meningioma. The targeted tumor is 110 × 102 × 109 mm and 14.7 mL in volume. The tumor was treated with median central and margin doses of 20 Gy and 12 Gy, respectively

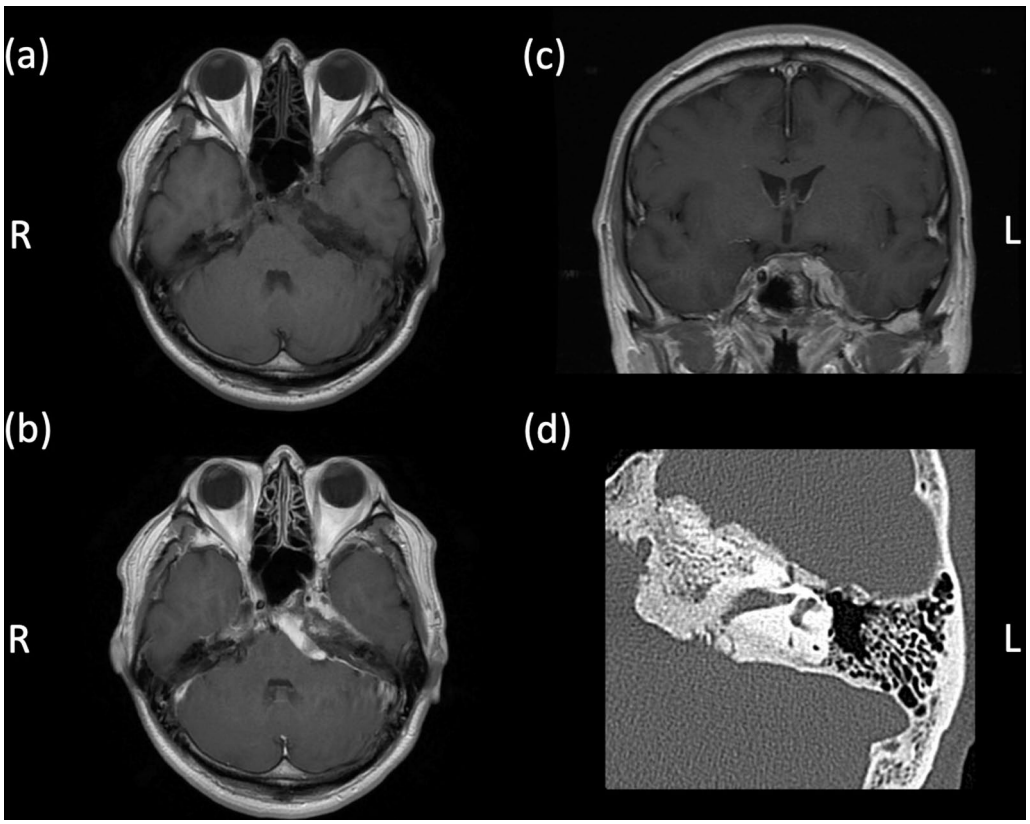

Fig. 3 Preoperative images of the cavernous sinus tumor 7 years after gamma-knife radiosurgery. **a** Axial image of T1-weighted brain MRI. **b** Axial view of gadolinium-enhanced T1-weighted brain MRI demonstrates that the tumor enlarged slightly toward the posterior fossa. **c** Coronal view of gadolinium-enhanced T1-weighted MRI. **d** Axial view of CT demonstrates progression of petrous bone thickening in internal auditory meatus

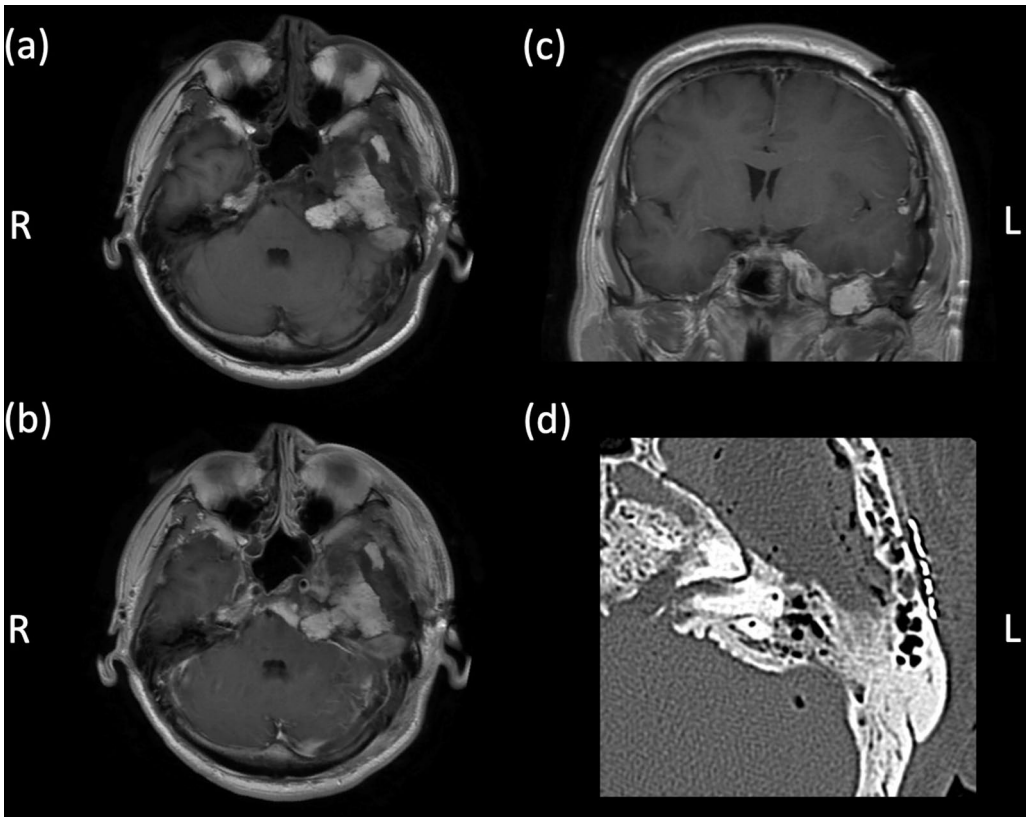

Fig. 4 Postoperative images of the cavernous sinus tumor within a week after surgery. **a** Axial view of T1-weighted brain MRI. **b** Axial view of gadolinium-enhanced T1-weighted brain MRI demonstrates that posterior part of the tumor removed and fat tissue packed. **c** Coronal view of gadolinium-enhanced T1-weighted MRI. **d** Axial view of CT demonstrates that thickened petrosal bone resected and internal auditory meatus opened

Discussion

It has been reported that the recurrence rate of completely resected cavernous sinus meningiomas is 10% and that of incompletely resected tumors is 15%, with an average follow-up period of 34 months [1]. Alternatively, GKRS has become a treatment option for cavernous sinus meningioma because of its good control rate of the tumor and fewer complications. Umekawa et al. reported that the 10-year progression-free survival was 87%, and that improvement in CN function reached 23% after stereotactic radiosurgery while maintaining a low CN deterioration or new CN deficits rate of 11% [7]. CN dysfunction as a radiation-induced adverse event occurs in 8–11% in the previous reports [3, 5–8]. Oculomotor nerve palsy, abducens nerve dysfunction, trigeminal sensory symptoms, and visual acuity deterioration have been reported as types of CN dysfunction after GKRS for cavernous sinus meningioma [5]. However, hearing impairments have not yet been reported in these patients to date. In other brain tumors, hearing impairment after stereotactic radiosurgery is typically known in vestibular schwannoma [2]. However, even in vestibular schwannoma, hearing impairment usually develops within three years after stereotactic radiosurgery [4].

In our case, the patient presented with hearing impairment 7 years after GKRS. Possible causes of hearing impairment included adverse events due to GKRS, stenosis of the internal auditory canal due to tumor enlargement, age-related changes, and other organic ear diseases. However, as mentioned above, no cases of hearing loss occurring so long after GKRS have been reported to date, and age-related hearing impairment was deniable, given the patient's age of 46 years. Additionally, the otolaryngologist's examination did not indicate any organic ear disease that could explain the hearing loss in this case, other than stenosis of the internal auditory canal. For these reasons, we concluded that hearing impairment was not an adverse event of GKRS but had resulted from internal auditory canal stenosis. Furthermore, the fact that the progression of hearing impairment stopped after decompression of the internal auditory canal also supports this conclusion. Lippitz et al. reported that 12.2% of meningioma patients who had undergone GKRS experienced local recurrence and 4.7%

required later surgery [4]. In the present case, removal of soft viable lesions that had enlarged after GKRS and opening of the internal auditory meatus were effective in controlling the tumor and stopping the worsening of hearing impairment. Further observation is necessary to evaluate the long-term prognosis.

Conclusion

A cavernous sinus meningioma with petrous bone invasion was partially removed 7 years after GKRS, and the internal auditory meatus was opened safely. The patient's hearing impairment did not progress after surgery. Removing tumors that could not be controlled by GKRS led to the cessation of tumor progression.

Abbreviations

CT	Computed tomography
CN	Cranial nerve
GKRS	Gamma-knife radiosurgery
MRI	Magnetic resonance imaging
PTA	Pure tone average

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Author contributions
All authors contributed to the study conception and design. YM, YA, and TS collected and interpreted the data and drafted the work. TS and TM revised the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
All patient data are included in this published article.

Declarations

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Not applicable.

Consent for publication
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Competing interests
The authors declare that they have no competing interests.

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