CASE REPORT

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Endoscope-assisted brain tumor removal overcomes the restriction of using intraoperative open magnetic resonance imaging in the suboccipital approach

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ABSTRACT

Intraoperative magnetic resonance imaging (iMRI) plays a crucial role in improving the precision of brain tumor surgeries. However, the use of iMRI can impose certain limitations on intraoperative head positioning. In regular microscopic surgery, head positioning is of utmost importance because an appropriate surgical field is important for the efficacy and safety of surgery. Therefore, in cases where adequate head positioning is difficult, usually, iMRI will not be utilized. Herein, we report an adult case of cerebellar astrocytoma whose tumor extended to the culmen of the cerebellum. Upon surgery via the suboccipital approach, the positional limitations imposed by iMRI led to an insufficient vertex-down position and limited surgical field, which hampered the removal of the upper portion of the tumor. However, this concern could be overcome when used in combination with an endoscope. The potential of iMRI applications is anticipated to be enhanced by overcoming positional limitations through combined endoscopic surgery. The use of multimodality in surgery is an optimal example of how surgical support equipment can also improve surgical outcomes. Here, we report on the new possibilities offered by multimodality.

Keywords: intraoperative MRI, positioning, multimodality, endoscope

Abbreviation:
iMRI: intraoperative magnetic resonance imaging

INTRODUCTION

Intraoperative magnetic resonance imaging (iMRI) plays a pivotal role in enhancing brain tumor surgery precision. This technology aids in achieving accurate tumor resection by evaluating the degree to which surgical plans are realized, including a real-time update of the navigation information.[1] It has remarkably contributed to increasing tumor resection rates.[2] Simultaneously, a randomized controlled trial using iMRI showed that improved resection degrees do not necessarily

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lead to worsening of neurological deficits.[3,4] Furthermore, iMRI can facilitate the early detection of intraoperative complications. Additionally, reports have highlighted its efficacy in pediatric brain tumor treatments.[5] Consequently, iMRI has become an indispensable tool in brain tumor surgeries, enhancing surgical outcomes and potentially improving patient prognoses.

However, the use of iMRI can impose certain limitations on intraoperative head positioning. As every surgeon would concur, head positioning is of utmost importance in regular microscopic surgery because an appropriate surgical field is crucial for the effectiveness and safety of surgery. For instance, in surgery using the prone position and suboccipital approach for cerebellar tumors extending to the cerebellar culmen, the extent of neck flexion (vertex down) is deemed important because the transverse sinus limits the field of view when approaching near the cerebellar culmen. At our institution, we use a permanent magnet 0.4T open MRI system, "APERTO," which has a 38-cm aperture.[6] During surgeries in the prone position using this MRI system, limitations to neck flexion (vertex down) are observed, rendering it challenging to secure a field of view for tumors extending to the culmen of the cerebellum. Herein, we report a case of cerebellar pilocytic astrocytoma in an adult extending to the apex of the cerebellum and demonstrate an effective strategy to overcome head positioning limitation.

CASE PRESENTATION

In 1980, a 3-year-old male presented with gait disturbance and was diagnosed with a cerebellar tumor. He underwent tumor resection. With the diagnosis of cerebellar astrocytoma, the patient received adjuvant chemoradiation therapy. He was followed up until 18 years old thereafter; however, as the tumor did not recur, his hospital visits were discontinued. However, in his early 40s, he presented with headache and ataxia. Head MRI revealed recurrence of a cerebellar tumor with obstructive hydrocephalus. Partial tumor removal, endoscopic third ventriculostomy, and postoperative chemotherapy were performed at a local hospital. The pathological diagnosis was pilocytic astrocytoma. Because chemotherapy was ineffective, with continuous enlargement of the residual tumor, he was referred to our hospital (Fig. 1A). Considering the diagnosis of pilocytic astrocytoma, we first decided to remove the tumor in the right cerebellar hemisphere and relieve the brain stem compression. Although a limitation in the field of view was present, tumor removal was successfully performed via the suboccipital approach and use of the iMRI system without any additional postoperative deficits (Fig. 1B). Pilocytic astrocytoma was again established as the diagnosis, although further genetic study revealed CDKN2A/B homozygous deletion. The patient was followed-up at our outpatient department; however, MRI revealed reenlargement of the residual tumor, again compressing the brainstem just 6 months after the prior surgery (Figs. 1C and D). Another surgery was performed using the same suboccipital approach and iMRI. Field-of-view limitation through the operative microscope was again encountered when exploring the cerebellar culmen. Thus, we introduced a neuroendoscope at this point. The neuroendoscope provided an extensive field of view for the culmen of the cerebellum, including the dorsal aspect of the midbrain (Fig. 2). With the aid of a neuroendoscope, the tumor could be removed except for the area invading the brain stem. After surgery, stereotactic radiotherapy was performed on the residual lesion (Fig. 3). Although the additional recurrence of the disease was observed and additional treatment was necessary, the patient has been able to walk unassisted with a walker until two years after the surgery.

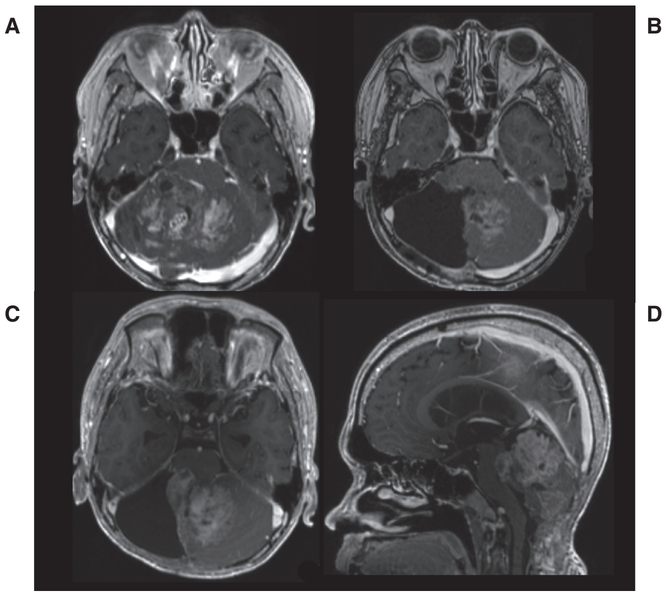

Fig. 1 Magnetic resonance imaging (MRI) obtained prior to second surgery at our institution
Contrast-enhanced T1-weighted image acquired during admission (A), after first surgery at our hospital (B), and 6 months after first surgery (C, axial; D, sagittal).

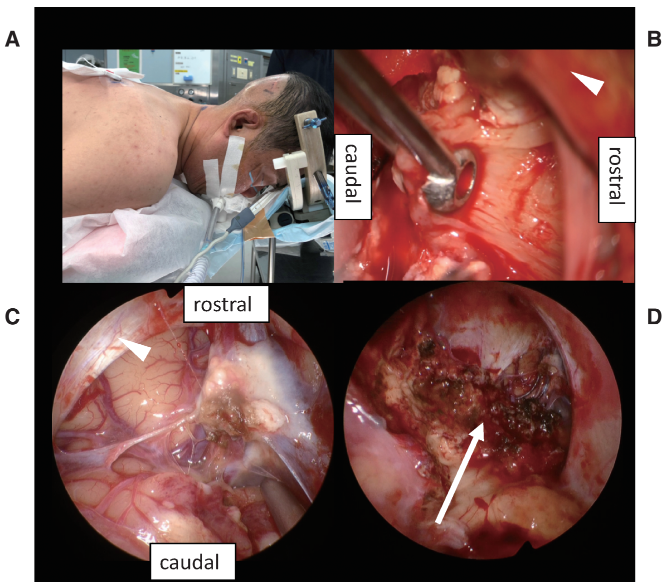

Fig. 2 Second surgery at our institution
Head position of the patient (A). Intraoperative view (B). The cerebellum is trailing caudally; however, the view of the superior surface of the cerebellum is restricted. View from endoscope, observing the dorsal brainstem from the inferior aspect of the cerebellar tentorium (C). Tumor removal was completed, leaving an area of tumor invasion on the dorsal brainstem (D).

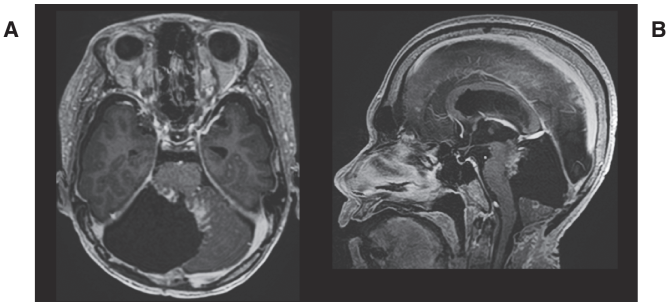

Fig. 3 Contrast-enhanced T1-weighted image obtained after second surgery at our hospital
Axial (A) and sagittal (B) images. After surgery, cyber knife therapy was performed on the residual lesion.

DISCUSSION

Normally, the midline suboccipital approach requires a vertex-down position that extends toward the neck.[7] Particularly, surgery with an extensive vertex-down position is required in cases in which the tumor extends to the culmen of the cerebellum. If the vertex-down position is inadequate, the transverse sinus becomes the upper limit of craniotomy, rendering it difficult to obtain a clear field of view during microsurgery.[8] In this paper, we report a case in which the positional limitations induced by iMRI resulted in insufficient vertex down and limited visual field, which impeded the removal of the upper portion of the tumor. However, the visual field dilemma could be overcome when combined with an endoscope. iMRI is increasingly recognized as a necessary device to facilitate surgery, and its use is becoming widespread. Especially, in tumor removal surgery, it is a useful device for correcting intraoperative brain shifts that occur with tumor removal and for visualizing intraoperative complications such as hemorrhage. However, depending on the surgical position required, it may be impossible to enter the gantry of the iMRI, or other restrictions may exist on its use depending on the individual surgery. Currently, as surgical techniques have diversified, if disadvantageous positional limitations can be overcome through multimodal surgery, as in this case, the technique may be used even more effectively.[9] In this case, the difficulties were overcome by the combined use of endoscopic surgery. Endoscopic surgery has expanded its indications from transnasal endoscopic pituitary surgery to brain tumors, including gliomas, making it a technique that can be utilized in a variety of neurosurgical situations at many institutions.

The present case was a rare case of recurrent pilocytic astrocytoma that developed long after the initial surgery. It has been reported that pilocytic astrocytoma with a CDKN2A/B homozygous mutation is usually more aggressive, although radiation received during childhood could have influenced this mutation. Chemotherapy with conventional vincristine plus etoposide was ineffective. Therapy for this tumor type needs to be improved by accumulating more cases.

The potential of iMRI applications is anticipated to be enhanced by overcoming positional limitations via combined endoscopic surgery. Utilizing multimodality in surgery is an optimal example of how a surgical support equipment can improve surgical outcomes, as reported here. However, there may be cases in which iMRI is rendered unsuitable, such as surgeries in the lateral position. However, if endoscopic surgery can be introduced from the beginning and surgery can be performed in the supine or prone position instead of the lateral position, it may be employed to any type of surgery. Here, we report on the new possibilities offered by multimodality.

CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

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