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Rigid endoscopic resection of deep-seated or intraventricular brain tumors

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Rigid endoscopic resection using a thick sheath (ViewSite) may be a viable method for the resection or biopsy of selected deep-seated brain tumors, such as thalamic gliomas and malignant lymphomas. Neuroendoscopic biopsy is one technique used for the histological verification of suspected brain tumors. There are a number of advantages to using this technique. For example, under direct vision, it is possible to carefully observe the tumor surface and avoid vessels during tumor resections. It is also possible to collect enough specimens for a pathological diagnosis. Eighteen consecutive patients safely underwent rigid endoscopic resection or biopsy using a thick sheath (ViewSite). The two-handed endoscopic technique that utilized a mounted rigid endoscope proved very useful and safe, since it enabled easy stanching of hemorrhages. The aim of this study was to demonstrate how to use a thick sheath for deep-seated or intraventricular tumors. The rigid endoscopic approach with a thick sheath provides an alternative medial approach with improved visualization and a wider working space.

Keywords: Rigid endoscopy, Deep-seated brain tumor, Intraventricular brain tumor, Two-handed endoscopic technique

Introduction

Brain retraction is necessary for approaching deep-seated intracranial tumors. Greenberg introduced the first self-retaining retractor for neurosurgery in 1981.¹ Strong retraction may cause significant brain and vascular damage.^{2,3} Some reports have demonstrated that tubular retractors can help minimize retraction injury in adult³⁻⁵ and pediatric patients.⁶ While the use of long retractors is necessary for deep lesions in the brain, they significantly reduce visualization. The rigid endoscopic technique using a thick tubular sheath provides an alternative medial approach that improves visualization and increases the working space. Furthermore, the two-handed technique is particularly useful for stanching hemorrhages. Although previous studies have described the procedures for this surgery, our study includes more cases, and for the first time, provides a detailed, step-by-step description of the techniques and demonstrates the amount of tissue that can be obtained when using this method.

Materials and Methods

A navigation system (BrainLab, Feldkirchen, Germany) was used to identify the entry and target points. The following instruments were used in this study: HOPKINS 2.7 mm endoscope (Karl Storz, Tuttlingen,

Germany); ViewSite sheath part# TC171107 (width: 17 mm, height: 11 mm, length: 7 cm; Vycor Medical, OH, USA); sucker for a 2.0 or 2.5 mm endoscope (Fujita Medical Instrument Co., Tokyo, Japan); and a UniARM endoscope holder (Mitaka Kohki Co., Tokyo, Japan).

Surgical procedures using a thick sheath (ViewSite)

Straight incisions were performed following a small craniotomy with a single burr hole. The dural and pial entry points were coagulated with bipolar electrocautery forceps, and the dura mater was opened widely and sharply. A corticotomy was performed on the non-eloquent cortex, and crossing a sulcus was avoided. A sheath was inserted with the help of a navigation guide to the preoperatively set target (Fig. 1A). A ventricular penetration needle was used to penetrate the ventricular wall since this is difficult to perform with the thick sheath. The sheath was then gently inserted under the guidance of the endoscope, because otherwise, the ventricular wall may have been pushed, or the ventricular shape may have been changed, or the sheath may have reached a location that we did not intend to reach. Suctioning of the ventricular wall, around the hole penetrated by the needle, was performed to create the surgical space. Double-handed manipulation during the operation was made possible using an endoscope holder

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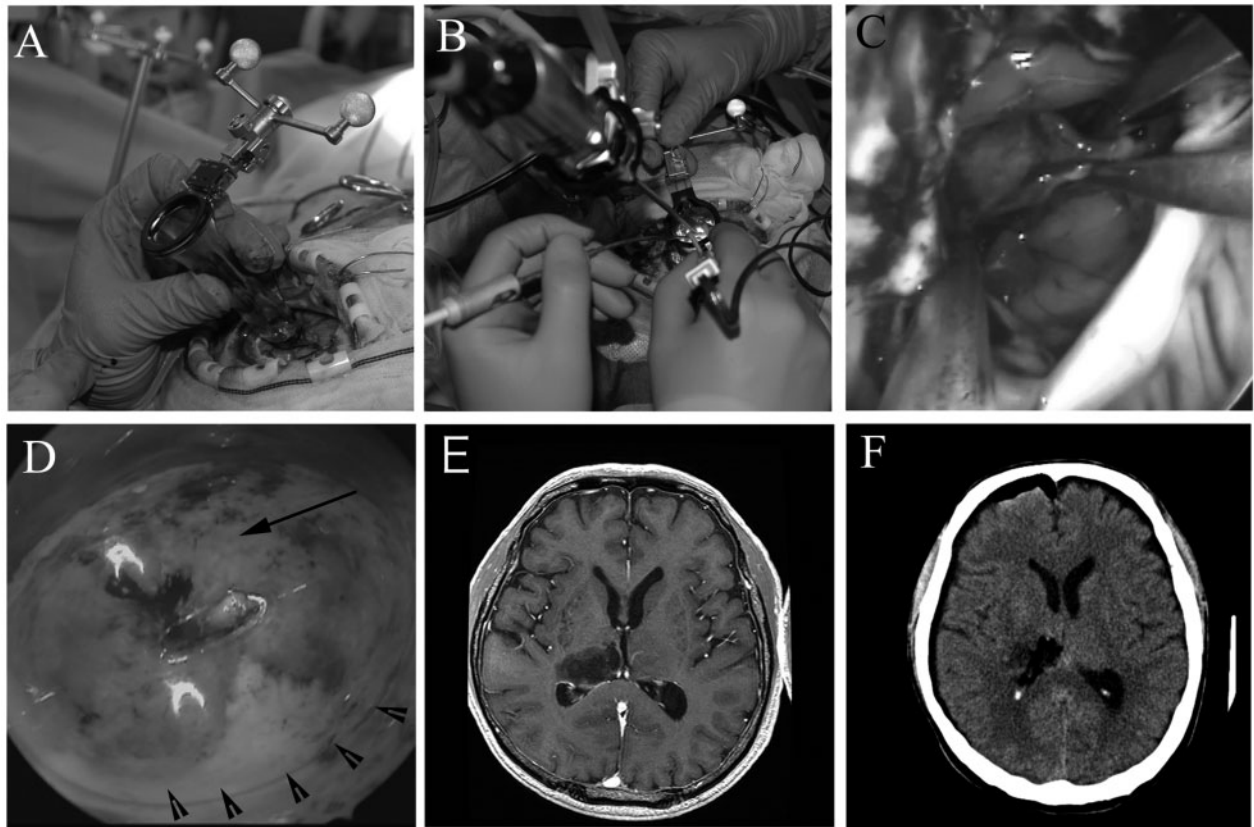


Figure 1 (A), Photograph showing the procedures for inserting the clear plastic sheath (ViewSite) into the brain using a navigation system (BrainLab). (B) The bimanual (bipolar forceps and suction) technique as visualized through the endoscope into the sheath. (C) Intraoperative photographs showing the procedures for dissecting the tumor from the surrounding normal brain tissue using the bimanual technique. These procedures are similar to those used when performing the operation under a microscope. (D) The superficial part of the tumor (arrow) with some surrounding white matter (arrowheads) is visible through the transparent sheath. Preoperative [contrast-enhanced T1-weighted axial, (E)] magnetic resonance (MR) images revealing a right thalamic low-grade glioma prior to endoscopic resection. Subtotal resection was achieved. (F) Postoperative computed tomography axial images obtained in a patient who underwent subtotal endoscopic resection of a thalamic low-grade astrocytoma; the patient was neurologically unchanged after surgery.

(Figs. 1B and 2). Dissection of the tumor from the normal brain tissue was easily conducted using this technique, similar to how it is performed under a microscope (Fig. 1C). In the case of transcortical white matter tumor resection, the superficial part of the tumor (arrow) with some surrounding white matter (arrowheads) was visible through the transparent sheath (Fig. 1D). Brain contusion in the trajectory was minimal. The diameter was approximately 15 mm or less immediately following sheath removal. After the operation, the trajectory continued to decrease.

The resected tumor volume was assessed by subtracting the residual tumor volume from the preoperative volume on gadolinium-enhanced T1-weighted magnetic resonance (MR) images pre- and postoperatively. Postoperative MR images were acquired within 3 days after surgery.

Results

Our 18 cases are summarized in Table 1. We were able to collect sufficient specimens for pathological diagnosis in all 18 patients. None of the patients had any complications after surgery.

An illustrative case

A 62-year-old male patient presented with a narrowing right-sided visual field and left-sided facial dysesthesia. Magnetic resonance (MR) imaging revealed a right thalamic mass with no enhancement (Fig. 1E). Transventricular surgical resection through the right posterior horn of the lateral ventricle was performed. Subtotal removal could be performed without any postoperative deterioration of the patient's neurological deficits (Fig. 1F). The pathological diagnosis was diffuse astrocytoma. The MIB-1 index was 20%. Radiochemotherapy was initiated.

Discussion

Previous studies have reported novel techniques for the pure endoscopic removal of brain tumors.⁷⁻¹⁰ Harris *et al.* demonstrated frame-based stereotactic techniques for intraventricular tumors.⁷ Considering the small diameter of endoscopes and the high number of available instruments for endoscopic surgery, it is possible to use this technique for almost complete resection of tumors, even thalamic lesions. The conduit (sheath) creates a space that allows for

bimanual dissection, a concept that was initially developed and modified for the stereotactic tubular retractor system.^{11–13} Microsurgical techniques with a similar translucent tubular retractor were reported for deep-seated or ventricular brain tumors.¹⁴ Some authors showed usefulness of the same retractor for deep-seated tumors in the brain;^{5,6} neuroendoscopic techniques with a similar tubular retractor for third ventricular tumors^{15,16} and intraparenchymal tumors¹⁷ were also reported. Recently, another report demonstrated the use of the same retractor.¹⁸ Collectively, these reports emphasize the usefulness of the translucent tubular retractor for ventricular and deep-seated brain tumors. While the procedures for this surgery have been published previously,^{15–18} our study provides data from more cases and offers a more detailed, step-by-step description of the techniques than previous studies. We also show, for the first time, how much tissue can be obtained when using this method.

There are a number of advantages to using this technique. For example, under direct vision, it is possible to carefully observe the tumor surface and avoid vessels during tumor resections. It is also possible to collect enough specimens for a pathological diagnosis. Ten of the 18 cases described in this article only underwent biopsies. Their diagnoses were malignant lymphoma, germinoma, or demyelinating tissues. With these diagnoses, additional resections should not be performed because removing additional tissue does not induce a better outcome. Although a stereotactic or neuronavigational needle biopsy might have been sufficient and less invasive in these cases, at least one study has suggested that

stereotactic needle biopsy specimens may not provide a sufficiently accurate diagnosis to reliably guide the treatment of brain neoplasms.¹⁹ In general, the accuracy rate of the stereotactic needle biopsy is 76–90%.^{19–22} The additional tumor tissue that can be removed safely with a tubular retractor for deep-seated brain tumors such as malignant lymphoma may not provide a better prognosis for longer life, but can provide a more accurate diagnosis, which could offer information about whether an additional tumor resection should be performed, for example, in malignant gliomas. The major limitation of using stereotactic techniques is related to the lack of intraoperative visualization and direct monitoring of the procedures, as well as to changes in the intracranial coordinates following cerebrospinal fluid loss during the management of intraventricular lesions.

Using the inserted route, we could observe some hemorrhages directly, and thus manipulate them while gradually pulling out the sheath. However, there are some disadvantages to using this technique. For one, the brain contusion on the trajectory to the tumor is larger in comparison to that using stereotactic biopsy. That said, we never experienced permanent or serious adverse effects when a particular trajectory was carefully planned. Hemorrhage control during endoscopic neurosurgery is critical due to the lack of suitable instruments for coagulation. Bleeding may cause significant visual deterioration during an endoscopic procedure. Moreover, it was slightly more challenging to manipulate some instruments in sheaths using endoscopic two-dimensional monitoring compared to using three-dimensional

Table 1 Patient characteristics

Cases	Age	Sex	Diagnosis	Tumor locations	Approaches	Resection	Tumor size	Extracted volume
1	62	M	DA	Rt. thalamus	T. Vent.	Subtotal	8.49 cm ³	7.98 cm ³
2	61	F	ML	Lt. frontal	T. Cort.	Biopsy	6.22 cm ³	1.32 cm ³
3	63	M	GBM	Lat. ventricle	T. Vent.	Partial	6.48 cm ³	2.29 cm ³
4	81	F	ML	Third & Lat. ventricle	T. Vent.	Biopsy	4.32 cm ³	1.24 cm ³
5	58	F	Meta	Rt. thalamus	T. Cort.	Gross total	7.22 cm ³	7.22 cm ³
6	54	F	ML	Lat. ventricle	T. Vent.	Biopsy	22.38 cm ³	6.24 cm ³
7	32	M	AA	Lt. frontal	T. Cort.	Gross total	18.42 cm ³	18.42 cm ³
8	72	M	GBM	Lt. frontal	T. Cort.	Gross total	24.08 cm ³	24.08 cm ³
9	26	M	Germ	Rt. putamen	T. Cort.	Biopsy	8.24 cm ³	4.08 cm ³
10	56	M	ML	Rt. Caud. head	T. Vent.	Biopsy	7.68 cm ³	1.86 cm ³
11	68	F	Meta	Rt. frontal	T. Cort.	Gross total	12.46 cm ³	12.46 cm ³
12	59	M	ML	Lt. frontal	T. Cort.	Partial	22.68 cm ³	12.88 cm ³
13	76	M	ML	Lt. thalamus	T. Vent.	Biopsy	8.58 cm ³	1.98 cm ³
14	32	M	Germ	Rt. thalamus	T. Vent.	Biopsy	6.78 cm ³	2.04 cm ³
15	55	F	MS	Rt. frontal	T. Cort.	Biopsy	18.32 cm ³	3.88 cm ³
16	70	M	ML	Lt. frontal	T. Cort.	Biopsy	10.22 cm ³	2.98 cm ³
17	26	M	CN	Rt. ventricle	T. Vent.	Partial	48.64 cm ³	30.44 cm ³
18	11	M	MS	Lt. thalamus	T. Vent.	Biopsy	12.68 cm ³	1.84 cm ³

M: male; F: female; CN: central neurocytoma; DA: diffuse astrocytoma; GBM: glioblastoma; Germ: germinoma; ML: malignant lymphoma; Meta: metastasis; MS: multiple sclerosis; AA: anaplastic astrocytoma; Rt: right; Lt: left; Caud: caudate; Lat: lateral; T: trans; Vent: ventricular; Cort: cortical. Gross-total resection was defined as no evidence of residual enhancement, subtotal resection was defined as anything more than 5% residual tumor, and partial resection was defined as anything more than 50% residual tumor. We were able to collect sufficient specimens for pathological diagnosis in all 18 patients. In addition, all patients were assessed immediately after surgery and long term for any evidence of neurological deficits or other surgical complications.

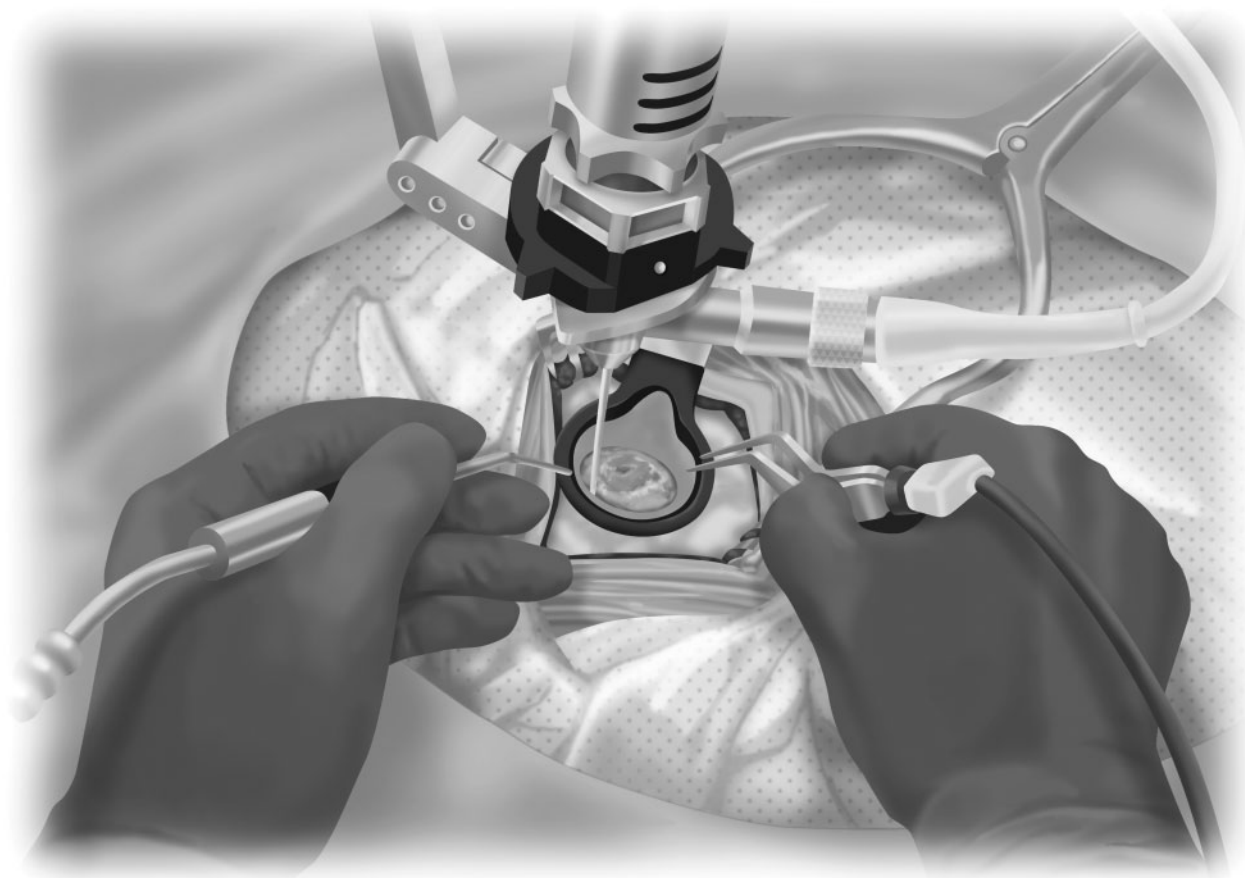


Figure 2 Schematic diagram showing the procedures for using the bipolar forceps and suction bimanually with a fixed rigid endoscope. The bimanual (bipolar forceps and suction) technique as visualized through the endoscope into the sheath.

microscopic procedures; however, the learning curve could be satisfactorily overcome.

We emphasize that rigid endoscopic resection is a very useful and safe approach for removing a target specimen. Rigid endoscopes, in comparison to flexible endoscopes, make bimanual procedures possible, which in turn makes it easier to control bleeding during operations (Fig. 2). Therefore, we believe that this technique is a safer, more reliable, and less invasive method for the treatment of deep-seated brain tumors.

Conclusions

Rigid endoscopic resection may be a viable method for the resection of certain deep-seated brain tumors, such as thalamic gliomas and malignant lymphomas. Further experience with this technique will help to determine its applicability and safety.

Disclaimer Statements

Contributors All authors are aware of and have consented to the submission. Each author has participated sufficiently in this article to take public responsibility for the content relevant to their contributions as following: analyzing the data and writing the article by Dr Akiyama as corresponding author, collecting the data by Dr Horita, Komatus,

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Conflicts of interest None of the authors have any conflict of interest concerning the financial, material, or methods used in this study.

Ethics approval This study was approved by the Sapporo Medical University Institutional Review Board (IRB # 25-103).

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