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Fully-Endoscopic Resection of Deep-Seated Pilocytic Astrocytoma Under 5-Aminolevulinic Acid Fluorescence Guidance: A Technical Note

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ABSTRACT

AIM: To improve the extent and safety of resecting these deep-seated tumors, we report a novel procedure of minimally invasive endoscopic resection of deep-seated pilocytic astrocytomas under the guidance of 5-aminolevulinic acid (5-ALA) fluorescence undescribed until now.

CASE DESCRIPTION: A 53-year-old male presented with a gradually progressing mild right hemiparesis. Imaging studies showed a solid tumor with degenerative cystic formation in the left basal ganglia. The tumor was removed endoscopically via right frontal small craniotomy. The tumor was positive for 5-ALA fluorescence and allowed better detection of the dissection margin of the solid tumor from the surrounding brain tissue. The histopathological diagnosis was pilocytic astrocytoma. No recurrence was observed on follow-up magnetic resonance imaging (MRI) 2 years after surgery, and the patient was fully independent after rehabilitation.

CONCLUSION: This minimally invasive technique, enhanced by intraoperative fluorescence, might be a safe and feasible alternative to open surgery in the removal of deeply located gliomas.

KEYWORDS: Neuroendoscopy, Photodynamic diagnosis, Pilocytic astrocytoma, 5-aminolevulinic acid

ABBREVIATIONS: GTR: Gross total resection, **5-ALA:** 5-aminolevulinic acid, **CT:** Computed tomography, **MRI:** Magnetic resonance imaging

INTRODUCTION

Pilocytic astrocytoma is a slow-growing, benign, and common brain neoplasm (19). The goal of treatment is gross total resection (GTR) (4); however, GTR is sometimes difficult to achieve as some pilocytic astrocytomas have deep-seated locations. In addition to the trauma of the approach, differentiating tumors from normal brain tissue within the limited surgical field can be difficult. Therefore, we report a minimally invasive endoscopic removal of a deep-seated pilocytic astrocytoma under the guidance of 5-aminolevulinic acid (5-ALA) fluorescence.

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MATERIAL and METHODS

A 53-year-old man with a history of type 1 neurofibromatosis presented with a 6-month-history of gradually progressing mild right hemiparesis. Computed tomography (CT) demonstrated a soft tissue dense mass in the left basal ganglia with a cystic component. On magnetic resonance imaging (MRI), the solid component and cyst wall were enhanced with contrast medium. Inside the solid component, multiple degenerative cystic formations were observed. The corticospinal tract was compressed toward the medial and caudal aspects of the tumor (Figure 1). Given these MRI findings and the patient's history, an initial diagnosis of pilocytic astrocytoma with a differential diagnosis of glioblastoma was made. We considered two alternative approaches in the treatment strategy: trans-sylvian craniotomy and endoscopic transcortical approach. With both methods, adequate extent of resection can be achieved, and intraoperative fluorescence with 5-ALA for guidance can be added. Therefore, the less invasive endoscopic approach was preferred.

RESULTS

Operation

An endoscope equipped for photodynamic diagnosis (D Light C system, KARL STORZ GmbH & Co., Tuttlingen, Germany) was inserted into the tubular retractor (ViewSite, Vycor Medical Inc, New York, USA). The white and violet lights could be easily changed using a foot switch. The lesion was manipulated using monoshaft forceps and suction tube inserted along with the endoscope (Figure 2). The surgeon manipulated the lesion using both hands with the suction tube and monoshaft forceps or bipolar cautery, while the assistant stabilized the endoscope and tubular retractor in position.

The patient received 20-mg/kg 5-ALA orally 3 h before surgery. In the supine position under general anesthesia and 3-pin head fixation, small craniotomy in the left frontal region was made. Corticotomy was made, and a tubular retractor (ViewSite 21 mm × 15 mm, 7 cm; Vycor Medical Inc., New York, USA) was inserted under navigation guidance (Vectorvision Sky; BrainLAB AG, Munich, Germany). Then, the cyst was opened using the endoscope, and the cyst wall showed red fluorescence under blue light and was dissected from the surrounding brain tissue under both white and blue lights. The solid part was slightly grayish and relatively firm; however, the dissection plane was sometimes unclear under white light. The red fluorescence enabled dissecting the solid part from the surrounding tissue and the fluorescence-emitting tumor, which was endoscopically removed (Figure 3).

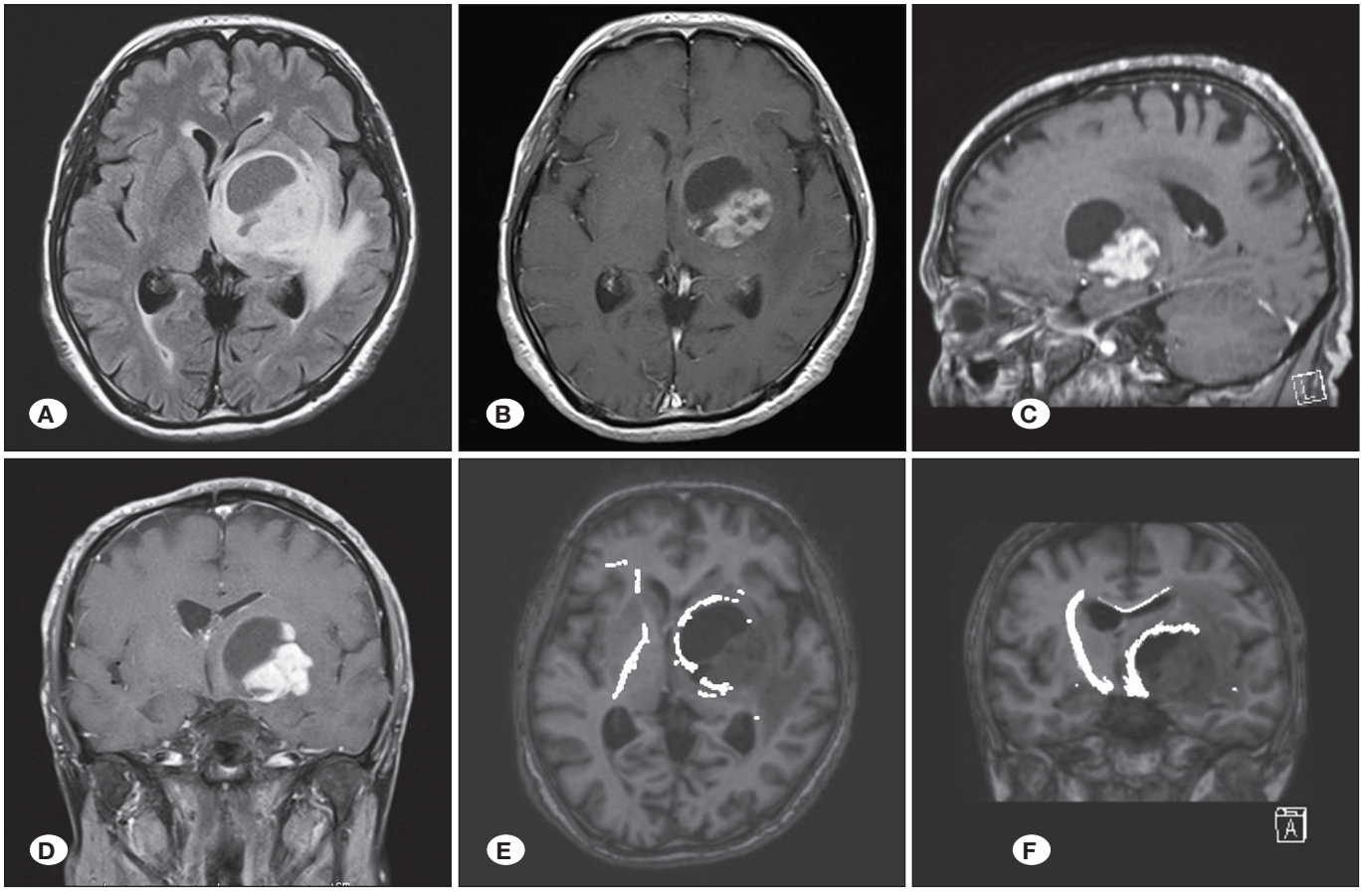

Figure 1: A) Fluid-attenuated inversion recovery and **(B,C,D)** contrast-enhanced T1-weighted imaging demonstrating a tumor with solid and cystic components. Inside the solid component, multiple degenerative cysts were observed. **E,F)** The corticospinal tract was compressed toward the medial and caudal aspects of the tumor.

Pathological Findings

The tumor cells consisted of bipolar cells with hair-like processes, and Rosenthal fibers were also observed. These cells contained hyperchromatic nuclei and were immuno-positive for glial fibrillary acidic protein, S100, synaptophysin, and Olig2. The Ki-67 index was as low as 5%, and neither mitosis nor necrosis was observed. The tumor was histopathologically diagnosed with pilocytic astrocytoma (Figure 4).

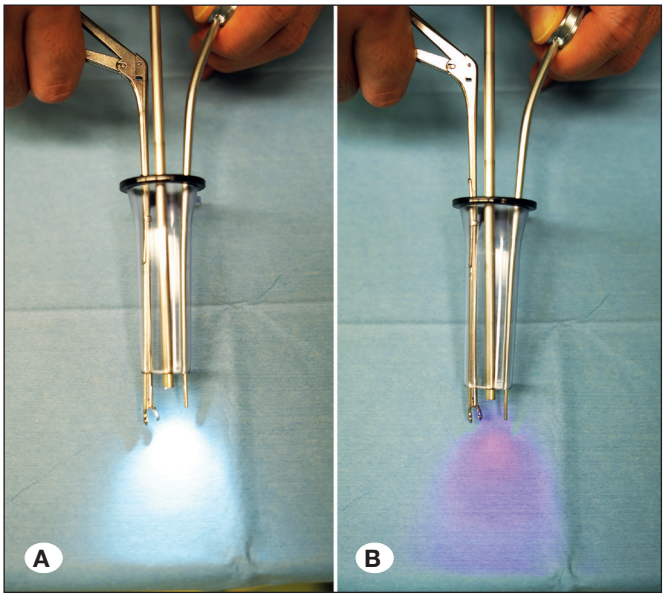

Figure 2: Instruments used for the endoscopic procedure. The endoscope, monoshaft forceps, and suction tube were inserted into the tubular retractor. The white **(A)** and violet **(B)** lights were changed using the foot switch.

Postoperative Course

With the pathological diagnosis of pilocytic astrocytoma, no additional adjuvant therapy was required. Although the patient's mild right hemiparesis persisted, currently, he is fully independent after rehabilitation, and no tumor recurrence was observed on follow-up MRI 2 years after the operation (Figure 5).

DISCUSSION

Pilocytic astrocytomas have a benign, slow-growing nature and favorable prognosis; however, postoperative recurrence rates have been reported as high as 43% (19). In a meta-analysis of adult pilocytic astrocytomas, patients who achieved GTR were less likely to have tumor recurrence than those treated with subtotal resection or biopsy, followed by radiation; thus, Bond et al. have concluded that the goal of surgery for adult pilocytic astrocytomas should be GTR whenever possible (4). A circumstance that makes GTR difficult is the deep-seated location of tumors, such as the brain stem or optic pathways. Although the extent and technique for managing a pilocytic astrocytoma located in the basal ganglia as in our case is controversial, the lesion should be removed as much as possible because the symptoms are caused by the mass. Initially, we planned to perform craniotomy and

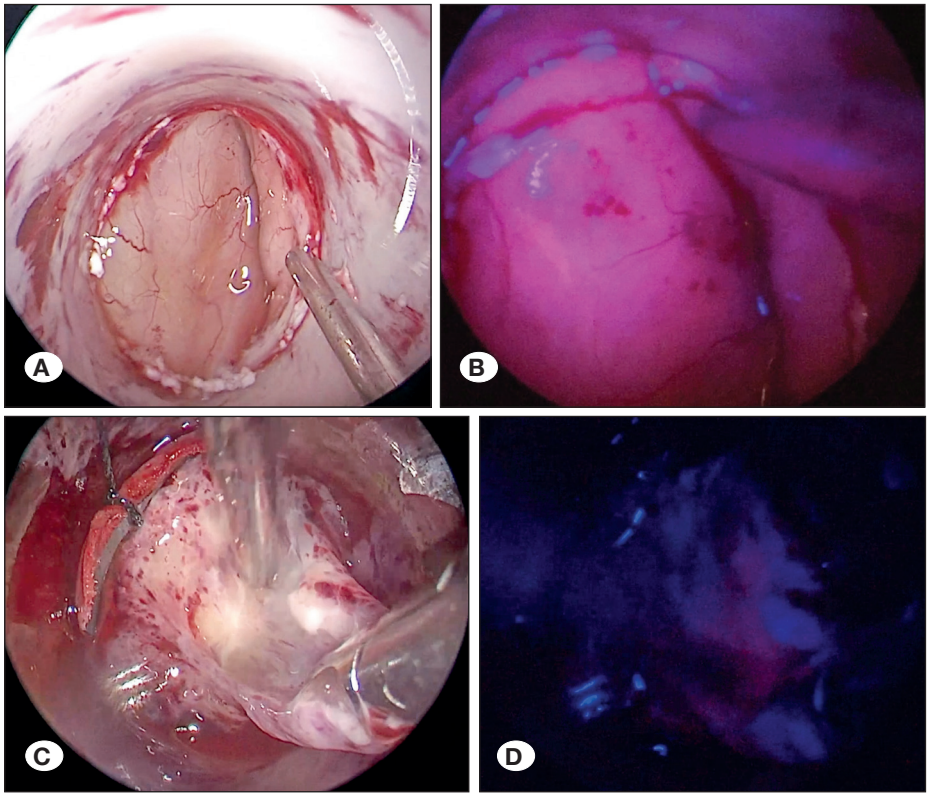

Figure 3: Intraoperative findings; **A,B)** solid component observed inside the cyst showing a strong fluorescence under blue light. **C,D)** Dissecting the grayish fluorescent tumor under blue light.

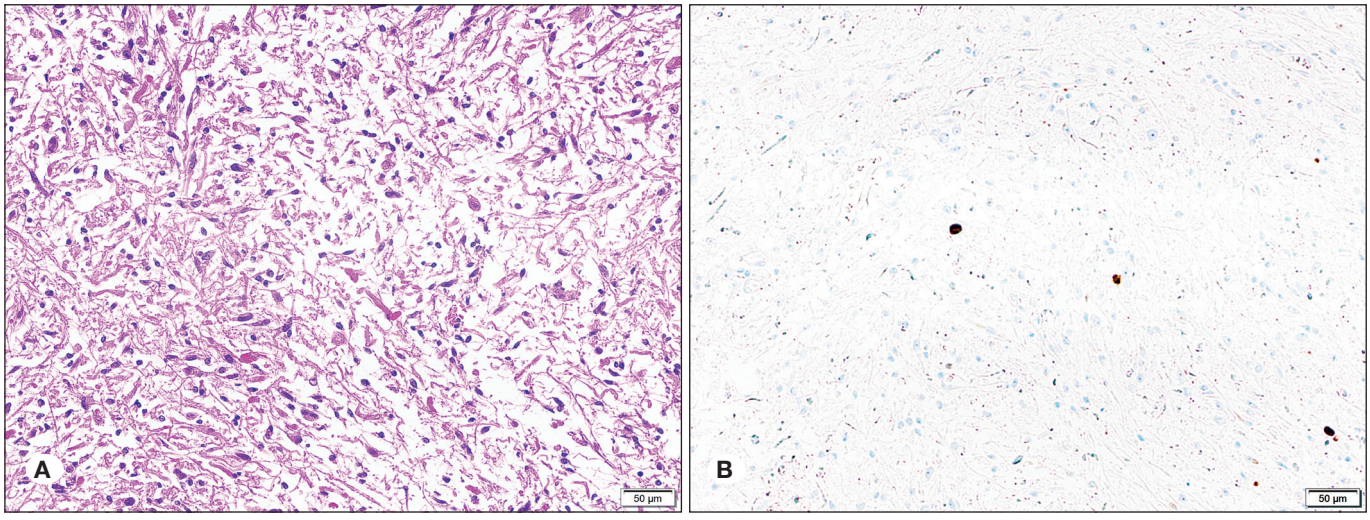

Figure 4: Pathological examination showing **(A)** bipolar cells with hair-like processes and Rosenthal fibers (hematoxylin and eosin stain, 200×). **B)** The Ki-67 index was 5%.

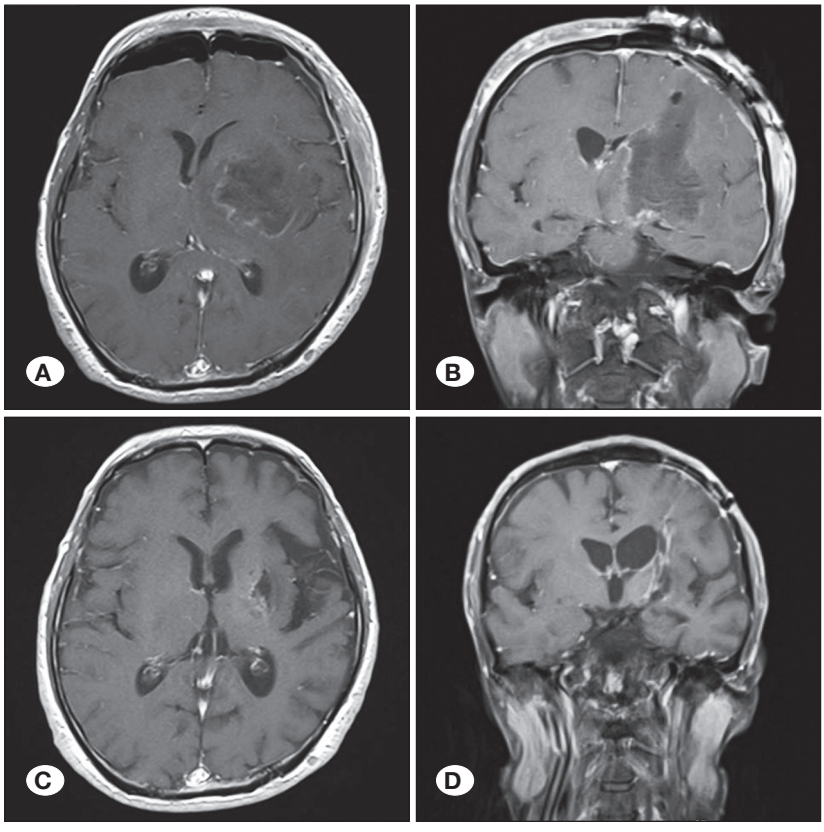

Figure 5: Postoperative MRI (2 days **(A,B)** and 1.5 years **(C,D)** after surgery) demonstrating gross total resection of the tumor.

the trans-sylvian approach, seeking the minimally invasive way. Given the location of the tumor in the globus pallidus and putamen, directly compressing the internal capsule, we considered that a method similar to endoscopic putaminal hemorrhage evacuation might be adopted. For endoscopic tumor resection, an endoscope, suction, and bipolar forceps should be inserted via a single port to perform more complex dissections and hemostasis through a wider corridor than required in hematoma evacuation.

The use of a tubular retractor for deep-seated brain lesions has been described since Kelly et al. first reported its use for stereotactic resection of intracranial tumors (9). Although surgeries using a tubular retractor system were initially performed under direct microscopic view (2,7,9,12,15,16), recent advancement of endoscopic techniques made them applicable in minimally invasive surgeries (1,5,6,8,10,13). The use of tubular retractors has advantages over conventional spatulas: the reduction of the retraction pressure and injury to surround-

ing brain tissue (11). The variability of the length and diameters of tubular retractors permits adequate visualization even for deep-seated lesions, permitting two-handed surgeries with microsurgical instruments.

5-ALA fluorescence-guided surgery is widely performed for malignant gliomas since Strummer et al. have reported its use for glioblastomas, improving the extent of tumor resection and progression-free survival (17). Various types of intracranial tumors other than malignant gliomas, such as metastatic brain tumor, malignant lymphoma, subependymoma, pituitary adenoma, meningioma, germ cell tumor, pilomyxoid astrocytoma, and pilocytic astrocytoma, demonstrate intense 5-ALA fluorescence (3,6,14,18). Fluorescence-guided endoscopic surgery has been reported for biopsy of germ cell tumors, malignant lymphomas, and malignant gliomas (6,18). Furthermore, Choo et al. have reported its extended use to achieve GTR of glioblastomas, metastatic brain tumors, and diffuse astrocytoma (6). The results of this study suggested the usefulness of fluorescence-guided endoscopic surgical resection of pilocytic astrocytoma to achieve GTR even with a deep-seated location.

CONCLUSION

The endoscopic removal of deep-seated pilocytic astrocytomas under 5-ALA fluorescence guidance allowed accurate and safe dissection of the lesion. Although further experience is needed to establish the benefits of endoscopic resection with 5-ALA fluorescence guidance, we believe that this technique can be applied safely for a broader range of deep-seated brain tumors.

AUTHORSHIP CONTRIBUTION

Study conception and design: RM

Data collection: RM, YA, NF, DK

Analysis and interpretation of results: RM

Draft manuscript preparation: RM

Critical revision of the article: KK

Other (study supervision, fundings, materials, etc...): YM

All authors (RM, YA, NF, DK, KK, YM) reviewed the results and approved the final version of the manuscript.

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