INTRODUCTION

Fluorescence guidance has been actively investigated as a tool that facilitates the gross total resection of brain tumors and has emerged as an additional preoperative technique, especially for surgeries involving high-grade gliomas [1-3]. Several reports that describe the application of fluorescence-guided resection of metastatic brain tumors, meningiomas [4], hemangioblastomas [5], pleomorphic xanthoastrocytomas, and ependymomas have been published, demonstrating the usefulness of the technique.

Extraventricular neurocytoma (EVN) is a rare type of brain tumor that displays a diverse range of clinical characteristics. We describe two cases involving fluorescence-guided resection of extraventricular neurocytoma using 5-aminolevulinic acid (5-ALA) and evaluate the efficacy of the technique. We found that the tumor reactions to 5-ALA differed depending on the histologic grade. This finding shows that the 5-ALA fluorescence reaction may potentially be used as a biomarker of the clinical behavior of these tumors. To our knowledge, this is the first report in which fluorescence-guided resection was utilized for the resection of extraventricular neurocytomas.

Key Words Extraventricular neurocytoma; Fluorescence guided surgery; 5-aminolevulinic acid.
composed of uniform round cells with or without clear cytoplasm. Some scattered cells showed astrocytic differentiation (Fig. 1E), and the mitotic rate was low (2/10 high power field). Immunohistochemical staining was positive for glial fibrillary acidic protein and synaptophysin, and the Ki-67 labeling index was 2.84% (Fig. 1F). The patient developed postoperative transient sensory aphasia, from which she fully recovered within one month. No adjuvant treatment was administered, and

Fig. 1. A: A transaxial T2-weighted MR image showing a diffuse high signal mass in the left temporal lobe. B: The mass was not enhanced in the coronal T1-weighted MR image with contrast. C and D: No fluorescence reaction was observed in any tumor tissue during surgery. E: The tumor composed of uniform round cells with or without clear cytoplasm (hematoxylin-eosin staining). F: Immunohistochemical staining for synaptophysin showing diffuse, strong reactivity in the tumor cells. MR: magnetic resonance.
no evidence of recurrence was observed at the regular imaging follow-up at 24 months after surgery.

**Case 2**

A 16-year-old girl presented with an episode of convulsion without any neurological deficits. MR images showed an intraxial mass with faint focal enhancement and high T2 signal intensity in the right high frontal lobe (Fig. 2A, B). The patient underwent fluorescence-guided tumor resection after a presumed diagnosis of low-grade glioma with anaplastic foci. The same procedure as that described for the above Case 1 was performed. Fluorescence was observed in some areas of the tumor tissue (Fig. 2C, D), and frozen biopsies were obtained from multiple sites. Three tissues that showed strong red flu-

![Image](image_url)

**Fig. 2.** A and B: A preoperative MRI scan showing a right high frontal mass with high signal intensity on a T2-weighted image and focal enhancement on a T1-weighted image with contrast. C and D: Intraoperatively, the mass showed positive fluorescence reaction and was red after illumination with ultrawave light of 440-nm wavelength. E: The tumor was composed of monotonous round cells with clear cytoplasm (hematoxylin-eosin staining). F: Immunohistochemical staining for synaptophysin showing diffuse, strong reactivity in the tumor cells. MRI: magnetic resonance imaging.
within the follow-up period, whereas ten of the 19 incom-pletely removed tumors recurred, regardless of adjuvant ra-
diotherapy. Recurrence occurred in five of ten classic EVNs and
five of nine atypical EVNs after incomplete removal. In the
Brat report, only one of ten atypical EVNs was completely re-
sected.

Gross total resection of benign brain tumors plays a signif-
icant role in prognosis. In malignant brain tumors, gross total
resection and overall prognosis seem to be highly correlated
[2]. Fluorescence-guided resection of brain tumors has been
extensively studied as a potential tool to help neurosurgeons
achieve maximal resection of gliomas. Recently, fluorescence-
guided surgery for brain tumors using 5-ALA has become
more widespread in clinical practice. The proposed mecha-
nisms of the increased 5-ALA uptake into neoplastic brain
tissue include the following: induced low permeability of the
blood-brain barrier, the presence of adaptable specific mem-
brane transporters, the reduced activity of ferrochelatase, the
lowering of the available iron due to chelators, the increased
activity of the enzymes that are involved in protoporphyrin
IX synthesis, elevated intracellular 5-ALA uptake, and decel-
erated protoporphyrin IX outflow from the cell [1]. Various
types of tumors were investigated for the use of 5-ALA for tu-
on resection, and the efficacy of the technique has been de-
monstrated in the literature [4,5]. To our knowledge, however,
the fluorescence reaction for EVN has yet to be reported.

In our 2 cases, the maximal safe resection under fluores-
cence guidance and intraoperative evoked potential monitor-
ing was performed in both patients who had EVN adjacent to
eloquent areas, and there were no permanent postoperative
neurological deficits. There were some areas that exhibited
the fluorescence reaction for 5-ALA within the tumor tissue,
and these areas correlated with histological EVN grade. We
discovered that the 5-ALA fluorescence reaction may help
increase the likelihood of complete resection of highly malign-
ant cell burden and may facilitate the intraoperative diag-
nosis of histological grade in EVNs. Furthermore, the histo-
logical grading system of EVNs has not been systemically de-
termined, the 5-ALA fluorescence reaction may have a po-
tential role as a biomarker for the prognosis of EVN. Further
study on the clinical experience with the 5-ALA fluorescence
reaction in EVNs is needed to confirm its role in the clinical
evaluation and treatment of these tumors.

In summary, the 5-ALA fluorescence reaction discrimi-
nated the histological grade of EVN and was helpful in terms
of achieving complete resection and determining the intraop-
erative diagnosis in atypical cases. This finding shows that the
5-ALA fluorescence reaction may be a potential biomarker of
the clinical behavior of EVN.
Conflicts of Interest

The authors have no financial conflicts of interest.

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