

Salvage Repeat Gross Total Resection Followed by VMAT-Based Focal Reirradiation for Locally Recurrent Pediatric Supratentorial Ependymoma: A Case Report

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Abstract

Case Report

Introduction/Background: Pediatric intracranial ependymomas are associated with a high risk of local recurrence despite maximal safe resection and postoperative radiotherapy. The role of reirradiation remains debated because of concerns regarding cumulative toxicity; however, modern conformal techniques allow focal retreatment in selected patients. **Case Presentation:** We report the case of a previously healthy girl diagnosed at 3 years and 7 months with a left frontoparietal supratentorial ependymoma. She underwent gross total resection (GTR) followed by adjuvant focal radiotherapy (59.4 Gy in 33 fractions). After nearly four years of disease control, she developed headaches and transient loss of consciousness. MRI showed an isolated local recurrence measuring 45 × 53 × 54 mm within the previous irradiation field, without neuraxial dissemination. A second GTR was achieved. Histopathological examination confirmed recurrent supratentorial ependymoma, not otherwise specified (NOS), with high-grade features including increased cellularity, focal necrosis, and elevated proliferative activity. Immunohistochemistry showed diffuse GFAP, S100, and vimentin expression with focal dot-like EMA positivity. Molecular classification was unavailable. Considering the localized recurrence, complete resection, prolonged disease-free interval, absence of dissemination, and preserved functional status, focal reirradiation was delivered using volumetric modulated arc therapy (VMAT) to 54 Gy in 30 fractions. Treatment was completed without interruption and was well tolerated, with no significant acute or late toxicity. At 19 months after reirradiation, the patient remained neurologically intact with sustained local control. **Conclusions:** Repeat GTR followed by VMAT-based focal reirradiation may represent an effective salvage approach for carefully selected children with recurrent supratentorial ependymoma.

Keywords: pediatric ependymoma; supratentorial ependymoma; recurrent ependymoma; reirradiation; case report.

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INTRODUCTION

Pediatric intracranial ependymomas account for approximately 5–10% of childhood central nervous system (CNS) tumors and remain among the most challenging pediatric brain neoplasms because of their high risk of local recurrence despite multimodal treatment. Current international guidelines recommend maximal safe surgical resection followed by focal postoperative radiotherapy as the standard treatment for localized disease, with gross total resection (GTR) representing the strongest predictor of progression-free survival (PFS) and overall survival (OS) [1–3]. Advances in conformal radiation techniques, including

intensity-modulated radiotherapy (IMRT), volumetric modulated arc therapy (VMAT), image-guided radiotherapy (IGRT), stereotactic radiotherapy (SRT), and proton therapy, have further improved dose conformity while reducing radiation exposure to surrounding normal tissues [4,5].

Despite these therapeutic advances, disease recurrence occurs in approximately 30–50% of children, most commonly within the original tumor bed, and remains the principal cause of treatment failure [3,6]. Repeat surgical resection is considered the cornerstone of salvage treatment whenever technically feasible, whereas conventional chemotherapy has demonstrated

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limited efficacy in recurrent ependymoma [2,6]. Historically, reirradiation was approached with caution because of concerns regarding cumulative radiation-induced toxicity, including radionecrosis, neurocognitive impairment, endocrine dysfunction, and cerebrovascular injury [7]. However, increasing evidence from institutional and multi-institutional studies has shown that modern focal reirradiation can improve local control and survival in carefully selected children with isolated recurrent disease, particularly after complete surgical resection, a prolonged disease-free interval, absence of neuraxial dissemination, and preserved functional status [8,9,11].

The 2021 World Health Organization (WHO) classification recognizes supratentorial ependymomas according to their molecular alterations, principally ZFTA fusion-positive and YAP1 fusion-positive subtypes [12–18]. Nevertheless, molecular profiling remains unavailable in many low- and middle-income countries, where diagnosis continues to rely on conventional histopathology and immunohistochemistry [12,14]. This limitation underscores the importance of reporting well-documented clinical experiences from resource-limited settings.

Herein, we report the case of a child with locally recurrent supratentorial ependymoma successfully treated with repeat gross total resection followed by VMAT-based focal reirradiation after previous postoperative radiotherapy. In addition to describing the clinical course, we present detailed dosimetric data and long-term follow-up, illustrating the feasibility and safety of this salvage strategy in a resource-limited setting and supporting the growing evidence favoring carefully selected reirradiation for recurrent pediatric ependymoma [8,9,11].

CASE REPORT

Primary Diagnosis and Treatment (2020)

A previously healthy 3-year-old girl (aged 3 years and 7 months at diagnosis) presented in April 2020 with progressive headaches, recurrent vomiting, and right-sided focal neurological deficits. Brain magnetic resonance imaging (MRI) revealed a $20 \times 15 \times 7$ mm left frontoparietal intra-axial lesion with imaging characteristics suggestive of a supratentorial glial tumor. Initial craniospinal evaluation showed no evidence of cerebrospinal fluid (CSF) dissemination (Figure 1).

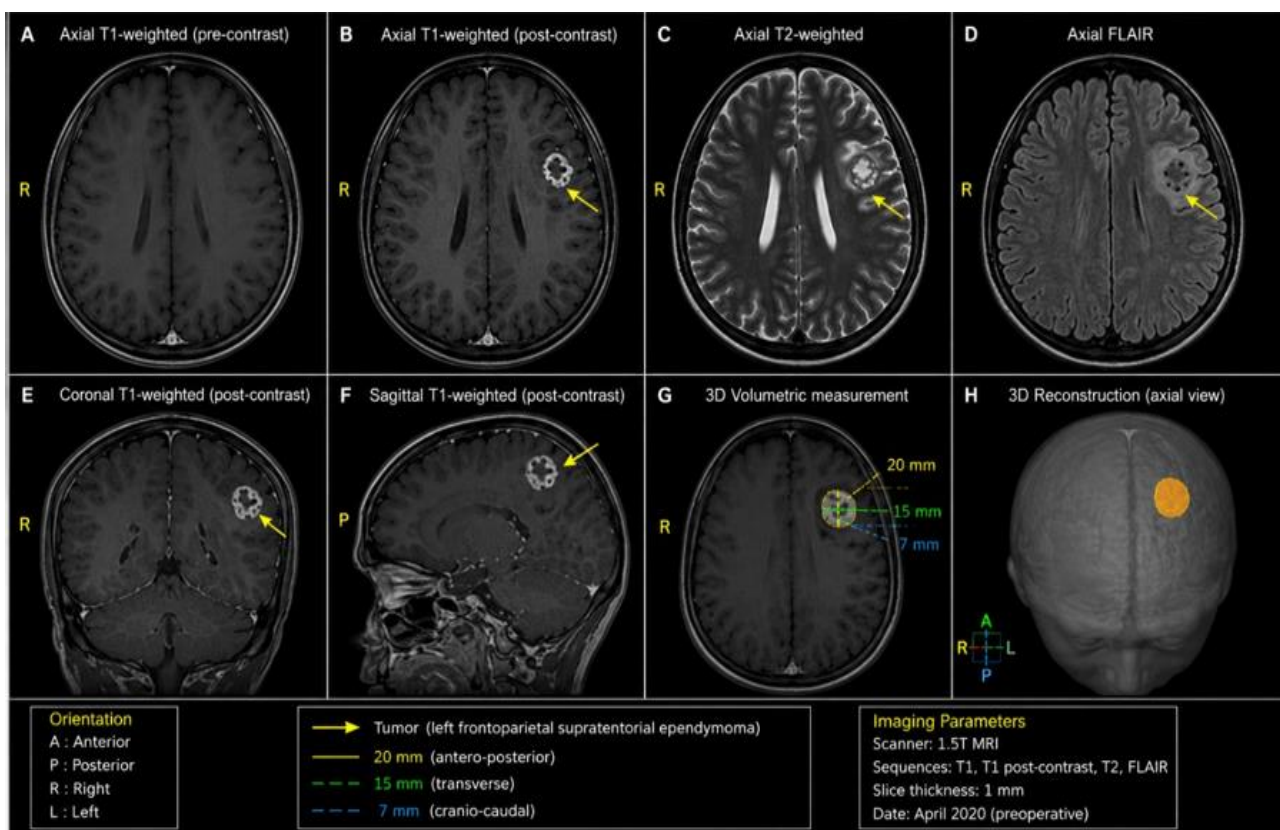


Figure 1: Preoperative brain MRI demonstrating a left frontoparietal supratentorial ependymoma in April 2020

(A) Axial T1-weighted pre-contrast MRI. (B–F) Axial, coronal, and sagittal T1-weighted post-contrast, T2-weighted, and FLAIR sequences demonstrating the enhancing left frontoparietal intra-axial tumor. (G) Three-dimensional volumetric measurement showing

tumor dimensions of 20 mm anteroposterior, 15 mm transverse, and 7 mm craniocaudal. (H) Three-dimensional axial reconstruction demonstrating the location of the lesion.

Abbreviations: MRI, magnetic resonance imaging; T1, T1-weighted; T2, T2-weighted; FLAIR, fluid-attenuated inversion recovery; 3D, three-dimensional; A, anterior; P, posterior; R, right; L, left.

The patient underwent gross total microsurgical resection on April 25, 2020. Early postoperative MRI confirmed complete macroscopic tumor removal. Histopathological examination of the primary surgical specimen demonstrated a moderately to highly cellular glial neoplasm composed of uniform round-to-oval cells arranged in characteristic perivascular pseudorosettes with occasional true ependymal rosettes. Focal areas of necrosis and microcalcifications were identified, together with increased mitotic activity. Immunohistochemical analysis showed diffuse expression of glial fibrillary acidic protein (GFAP), S100 protein, and vimentin, whereas epithelial membrane antigen (EMA) demonstrated the characteristic focal paranuclear dot-like staining pattern. Chromogranin, synaptophysin, and smooth muscle actin were negative, excluding alternative neuronal or mesenchymal differentiation. The Ki-67 proliferation index reached approximately 20% within hotspot areas, indicating increased proliferative activity.

According to the current WHO Classification of Tumors of the Central Nervous System (2021), the lesion was diagnosed as supratentorial ependymoma, NOS, showing high-grade histopathological features. Molecular characterization, including assessment of

ZFTA fusion status, could not be performed because advanced molecular diagnostic techniques were unavailable at our institution.

Following multidisciplinary pediatric neuro-oncology board discussion, adjuvant focal radiotherapy was recommended because of the high risk of local recurrence associated with the high-grade histopathological features. Treatment was delivered between June 8 and August 7, 2020, using three-dimensional conformal radiotherapy (3D-CRT) to a total dose of 59.4 Gy in 33 fractions (1.8 Gy/fraction). Treatment planning achieved adequate coverage of the postoperative tumor bed while respecting dose constraints for adjacent organs at risk (OARs). Radiotherapy was completed without interruption or clinically significant acute toxicity. The patient underwent regular clinical and MRI surveillance and remained free of disease for almost four years, demonstrating normal neurological development.

Recurrence and Salvage Management (2024)

In February 2024, the patient presented with recurrent headaches accompanied by transient episodes of loss of consciousness. Brain MRI demonstrated a $45 \times 53 \times 54$ mm contrast-enhancing left frontoparietal intra-axial mass arising within the previously irradiated tumor bed, highly suggestive of isolated local recurrence. No leptomeningeal or distant intracranial dissemination was identified (Figure 2).

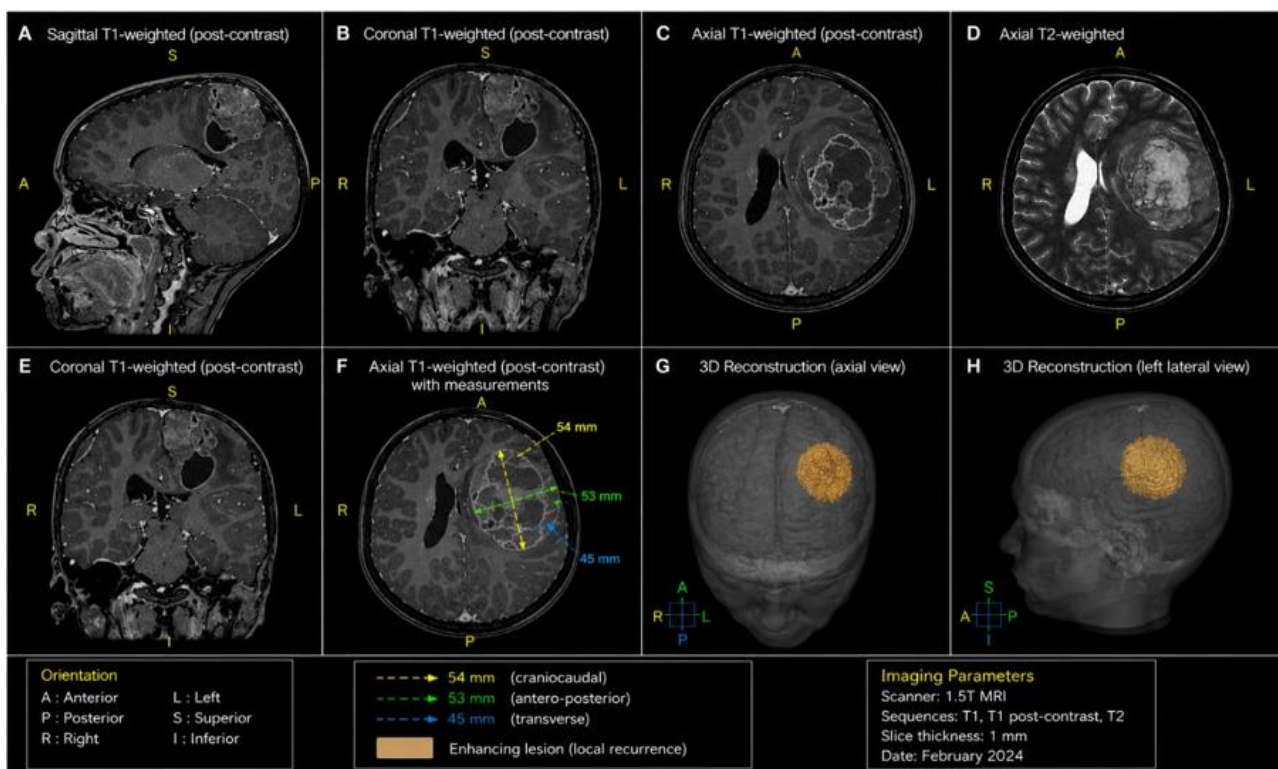


Figure 2: Brain MRI demonstrating isolated local recurrence within the previous tumor bed in February 2024, measuring $45 \times 53 \times 54$ mm

(A–E) Sagittal, coronal, and axial T1-weighted post-contrast MRI sequences demonstrating a large enhancing left frontoparietal intra-axial lesion. (F) Axial T1-weighted post-contrast image with measurements of the enhancing recurrent lesion: 54 mm craniocaudal, 53 mm anteroposterior, and 45 mm transverse. (G–H) Three-dimensional reconstructions showing the location and extent of the enhancing local recurrence.

Abbreviations: MRI, magnetic resonance imaging; T1, T1-weighted; T2, T2-weighted; 3D, three-dimensional; A, anterior; P, posterior; R, right; L, left; S, superior; I, inferior.

Over the following weeks, neurological deterioration occurred with progressive right hemiparesis and signs of increased intracranial pressure. Brain computed tomography (CT) confirmed tumor progression associated with early temporal herniation, prompting urgent surgical intervention. On April 5, 2024, the patient underwent repeat craniotomy with gross total resection of the recurrent tumor.

Histopathological examination of the recurrent lesion demonstrated morphological findings comparable to those of the primary tumor. The neoplasm consisted of a moderately cellular glial proliferation with prominent perivascular pseudorosettes and occasional true ependymal rosettes, associated with increased cellularity, focal necrosis, and elevated mitotic activity. Immunohistochemical staining again demonstrated diffuse positivity for GFAP, S100 protein, and vimentin, together with focal dot-like EMA immunoreactivity. The Ki-67 proliferation index remained approximately 20%, supporting persistent high proliferative activity.

Based on the 2021 WHO Classification, the recurrent lesion was classified as supratentorial ependymoma, NOS, with high-grade histopathological features. Molecular subclassification was not available because testing for ZFTA and YAP1 gene fusions could not be performed.

Following multidisciplinary institutional discussion, salvage focal reirradiation was recommended based on the isolated local recurrence, prolonged disease-free interval (~4 years), achieved GTR, absence

of neuraxial dissemination, and excellent performance status (ECOG 0).

Radiotherapy Planning and Dosimetry

The patient underwent CT simulation in the supine position using a customized thermoplastic head mask to ensure reproducible immobilization. Planning CT images were rigidly co-registered with the preoperative contrast-enhanced brain MRI to accurately define the recurrent tumor extent. The preoperative gross tumor volume (GTV) served as a guide for target delineation. The clinical target volume (CTV) was defined as the postoperative surgical cavity encompassing the initial tumor bed with a 5-mm isotropic margin to account for potential microscopic residual disease. A 3-mm margin was subsequently added to generate the planning target volume (PTV) to compensate for setup uncertainties.

Treatment planning was performed using the Monaco® Treatment Planning System (version 6.1.4; Elekta AB, Stockholm, Sweden). Reirradiation was delivered via VMAT on a Versa HD™ linear accelerator equipped with an Agility™ multileaf collimator. A total dose of 54 Gy in 30 fractions (1.8 Gy per fraction, five fractions per week) was prescribed to the PTV. Daily image guidance with cone-beam computed tomography (CBCT) was performed before each treatment session to verify positioning.

OARs were contoured according to international pediatric neuro-oncology guidelines. Treatment optimization prioritized target coverage while strictly minimizing cumulative doses to overlapping normal tissues to lower the risk of radionecrosis. Dosimetric plan evaluation was performed via dose–volume histogram (DVH) analysis.

The salvage VMAT plan achieved excellent target coverage, with 98.36% of the PTV receiving at least 95% of the prescribed dose, a homogeneity index (HI) of 1.08, and highly satisfactory dose conformity while respecting all predefined OAR constraints. Representative dose distributions and DVHs of the initial 3D-CRT plan and the salvage VMAT plan are presented in Figure 3. Detailed dosimetric parameters for both courses are summarized in Table 1.

Table 1: Comparative Dosimetric Parameters of the Initial Postoperative 3D-CRT and Salvage VMAT Reirradiation Plans

Structure	3D-CRT (59.4 Gy / 33 fractions)			VMAT Reirradiation (54 Gy / 30 fractions)		
	Dmean (Gy)	Dmax (Gy)	V95% (%)	Dmean (Gy)	Dmax (Gy)	V95% (%)
PTV	58.68	61.82	96.51	53.86	57.16	98.36
Healthy brain	7.17	59.28	–	11.00	53.93	–
Brainstem	0.37	0.77	–	0.99	2.33	–
Optic chiasm	0.25	0.27	–	0.76	0.85	–
Right optic nerve	0.18	0.21	–	0.52	0.64	–

Left optic nerve	0.20	0.26	—	0.55	0.69	—
Pituitary gland	0.24	0.25	—	0.63	0.74	—

Abbreviations: 3D-CRT, three-dimensional conformal radiotherapy; VMAT, volumetric modulated arc therapy; PTV, planning target volume; Dmean, mean dose; Dmax, maximum dose; V95%, percentage of the planning target volume receiving at least 95% of the prescribed dose.

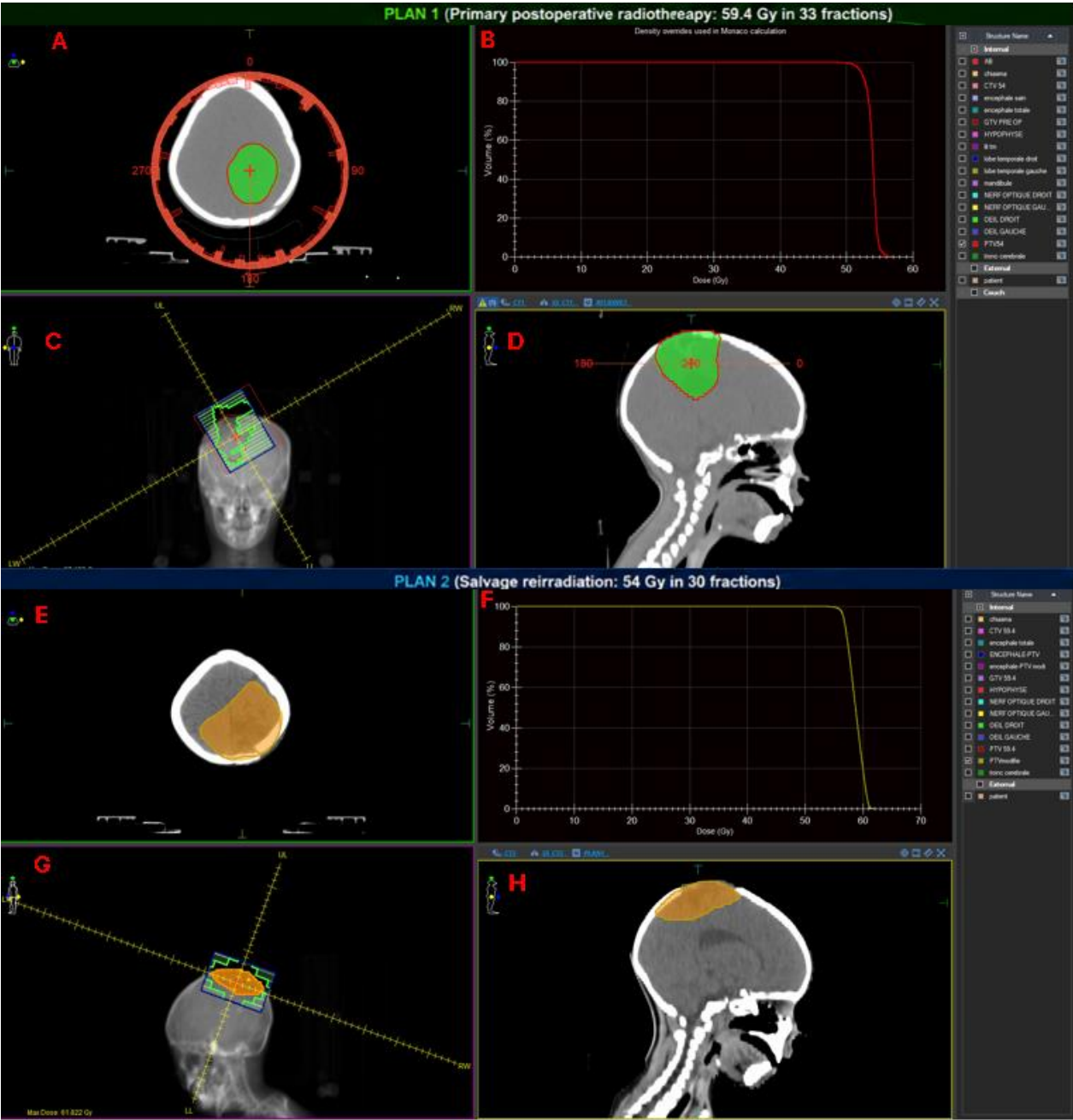


Figure 3: Dosimetric comparison of the initial postoperative 3D-CRT plan and salvage VMAT reirradiation. (A–D) Initial postoperative plan delivering 59.4 Gy in 33 fractions, including axial, dose–volume histogram, coronal, and sagittal views. (E–H) Salvage VMAT plan delivering 54 Gy in 30 fractions, including axial, dose–volume histogram, coronal, and sagittal views

Follow-up

The second course of radiation was completed without interruption or acute toxicity. At the first post-treatment evaluation in January 2025, the patient was asymptomatic and neurologically intact. Brain and cervical spine MRIs demonstrated only expected post-

treatment modifications without residual or recurrent disease.

Subsequent MRI surveillance in July 2025 demonstrated stable post-therapeutic findings. At the latest follow-up in May 2026 (approximately 19 months

post-reirradiation and over six years from the initial diagnosis), the patient remained completely

asymptomatic, neurologically intact, and in sustained radiological remission (Figure 4).

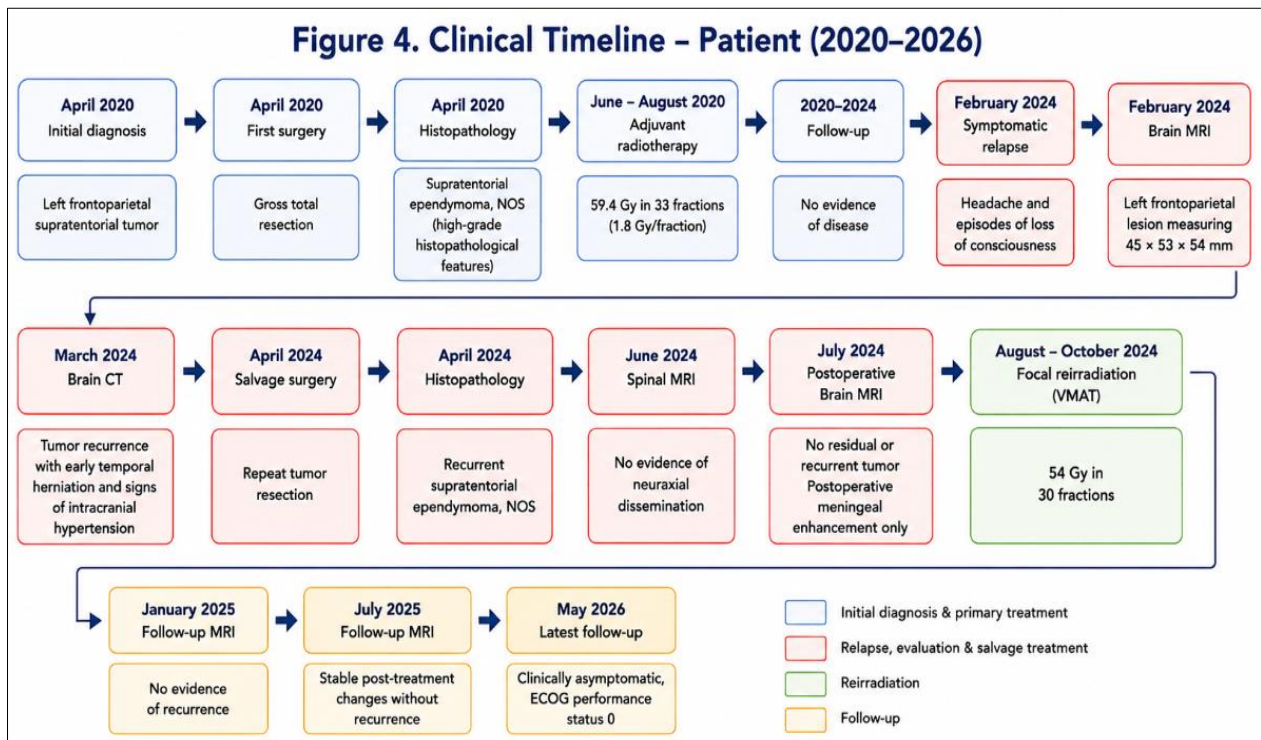


Figure 4: Chronological timeline summarizing the patient's diagnosis, primary treatment, recurrence, salvage surgery, VMAT-based reirradiation, and clinical follow-up from 2020 to 2026

Abbreviations: CT, computed tomography; ECOG, Eastern Cooperative Oncology Group; Gy, Gray; MRI, magnetic resonance imaging; NOS, not otherwise specified; VMAT, volumetric modulated arc therapy; WHO, World Health Organization.

DISCUSSION

Pediatric intracranial ependymoma remains one of the most challenging central nervous system (CNS) tumors in childhood because of its high propensity for local recurrence despite multimodal treatment. Current international guidelines recommend maximal safe surgical resection followed by focal postoperative radiotherapy as the standard of care for localized disease, with gross total resection (GTR) consistently representing the strongest predictor of progression-free survival (PFS) and overall survival (OS) [1,2]. Nevertheless, approximately 30–50% of patients develop recurrence, most frequently within the original tumor bed, making effective salvage therapy essential for improving long-term outcomes [3,6].

The present case illustrates a favorable but relatively uncommon clinical scenario in which an isolated late local recurrence was successfully managed with repeat GTR followed by conventionally fractionated volumetric modulated arc therapy (VMAT)-based focal reirradiation. At 19 months after completion of reirradiation, the patient remained neurologically intact, free of radiological recurrence, and without clinically significant treatment-related toxicity. This favorable outcome is consistent with increasing evidence

indicating that carefully selected children with localized recurrent ependymoma may achieve durable disease control through an aggressive multidisciplinary salvage strategy [8–11].

Among the prognostic factors reported in the literature, the extent of surgical resection remains the most important determinant of outcome. Merchant *et al.*, established maximal safe resection followed by postoperative conformal radiotherapy as the cornerstone of primary treatment [1], whereas Cage *et al.*, demonstrated that repeat GTR at recurrence is associated with significantly improved survival compared with subtotal resection [3]. Likewise, the EANO guidelines emphasize the importance of maximal resection whenever technically feasible before considering additional local treatment [2]. In our patient, complete macroscopic resection was achieved during both the initial surgery and salvage surgery, minimizing residual disease before reirradiation and likely contributing to the sustained local control observed.

Historically, reirradiation was considered a high-risk therapeutic strategy because of concerns regarding cumulative radiation-induced toxicity, including radionecrosis, neurocognitive impairment, endocrine dysfunction, and cerebrovascular injury.

However, the recent Pediatric Normal Tissue Effects in the Clinic (PENTEC) review demonstrated that the incidence of severe toxicity can be minimized when cumulative dose constraints are respected and modern conformal radiotherapy techniques are employed [7]. Advances in radiation delivery, including IMRT, VMAT, image-guided radiotherapy, and proton therapy, have substantially improved target conformity while reducing unnecessary irradiation of surrounding normal tissues, thereby improving the therapeutic ratio for children requiring retreatment [4,5].

Evidence supporting reirradiation for recurrent pediatric ependymoma has steadily accumulated over the past decade. Bouffet *et al.*, demonstrated a survival benefit associated with repeat irradiation in children with recurrent ependymoma [9]. Subsequently, Tsang *et al.*, reported improved progression-free survival following focal reirradiation, particularly in patients who underwent complete surgical resection before retreatment [8]. In patients presenting with disseminated relapse, craniospinal reirradiation followed by a focal boost has also been associated with encouraging disease control in carefully selected cases [10]. More recently, the multi-institutional study by Mak *et al.*, confirmed that repeat surgery combined with focal reirradiation provides superior local control compared with surgery alone, further supporting a multidisciplinary salvage approach [11].

Several favorable prognostic factors likely contributed to the excellent outcome observed in our patient. These included isolated local recurrence without neuraxial dissemination, a prolonged disease-free interval of approximately four years, repeat gross total resection, excellent functional status (ECOG 0), and treatment with highly conformal VMAT using daily cone-beam CT guidance. In addition, meticulous dosimetric optimization achieved excellent planning target volume coverage while maintaining acceptable doses to surrounding organs at risk, thereby reducing the likelihood of cumulative radiation-induced toxicity [4,7].

An important strength of this report is the detailed dosimetric comparison between the initial irradiation course and salvage reirradiation. Such comprehensive dosimetric documentation provides practical information for clinicians considering reirradiation in similar situations. Furthermore, this case originated in a resource-limited setting where molecular profiling was unavailable. Although the current WHO classification recommends molecular classification of supratentorial ependymomas and recognizes biologically distinct molecular subgroups [12–18], many centers continue to rely on conventional histopathology and immunohistochemistry because advanced molecular diagnostics remain inaccessible. Our case demonstrates that careful multidisciplinary management integrating surgery, modern radiotherapy techniques, and rigorous

imaging follow-up can still achieve favorable clinical outcomes despite these limitations.

The principal limitation of this report is its single-patient design, which limits the generalizability of the findings. In addition, molecular characterization, including assessment of ZFTA and YAP1 fusion status, could not be performed. Nevertheless, this case contributes to the growing body of evidence supporting repeat gross total resection followed by focal conformal reirradiation as an effective salvage strategy for carefully selected children with locally recurrent supratentorial ependymoma [8–11].

CONCLUSION

This case demonstrates that repeat gross total resection followed by focal VMAT-based reirradiation can provide durable local disease control with acceptable toxicity in carefully selected children with isolated recurrent supratentorial ependymoma. Our experience supports the use of highly conformal reirradiation as a component of multidisciplinary salvage management for recurrent pediatric ependymoma.

REFERENCES

1. Merchant TE, Li C, Xiong X, *et al.*, Conformal radiotherapy in children with newly diagnosed ependymoma: a prospective, multicentre phase II study. *Lancet Oncol.* 2009;10(3):258–266. doi:10.1016/S1470-2045(08)70342-5.
2. Rudà R, Reifenberger G, Frappaz D, *et al.*, EANO guidelines for the diagnosis and treatment of ependymal tumors. *Neuro Oncol.* 2018;20(4):445–456. doi:10.1093/neuonc/nox166.
3. Cage TA, Clark AJ, Aranda D, *et al.*, A systematic review of treatment outcomes in pediatric patients with intracranial ependymomas. *J Neurosurg Pediatr.* 2013;11(6):673–681. doi:10.3171/2013.2.PEDS12345.
4. Indelicato DJ, Bradley JA, Rotondo RL, *et al.*, Outcomes following proton therapy for pediatric ependymoma. *Acta Oncol.* 2018;57(5):644–648. doi:10.1080/0284186X.2017.1413248.
5. Lee J, Chung SY, Han JW, *et al.*, Treatment outcome of anaplastic ependymoma under the age of 3 treated by intensity-modulated radiotherapy. *Radiat Oncol J.* 2020;38(1):26–34. doi:10.3857/roj.2020.00073.
6. Ritzmann TA, Rogers HA, Paine SML, *et al.*, A retrospective analysis of recurrent pediatric ependymoma reveals extremely poor survival and ineffectiveness of current treatments across central nervous system locations and molecular subgroups. *Pediatr Blood Cancer.* 2020;67(9):e28426. doi:10.1002/pbc.28426.
7. Ajithkumar T, Avanzo M, Yorke E, *et al.*, Brain and Brain Stem Necrosis After Reirradiation for Recurrent Childhood Primary Central Nervous System Tumors: A PENTEC Comprehensive

- Review. *Int J Radiat Oncol Biol Phys.* 2024;119(2):655–668. doi:10.1016/j.ijrobp.2023.12.043.
8. Tsang DS, Burghen E, Klimo P Jr, *et al.*, Outcomes After Reirradiation for Recurrent Pediatric Intracranial Ependymoma. *Int J Radiat Oncol Biol Phys.* 2018;100(2):507–515. doi:10.1016/j.ijrobp.2017.10.002.
 9. Bouffet E, Hawkins CE, Ballourah W, *et al.*, Survival benefit for pediatric patients with recurrent ependymoma treated with reirradiation. *Int J Radiat Oncol Biol Phys.* 2012;83(5):1541–1548. doi:10.1016/j.ijrobp.2011.10.039.
 10. Tsang DS, Murray L, Ramaswamy V, *et al.*, Craniospinal irradiation as part of reirradiation for children with recurrent intracranial ependymoma. *Neuro Oncol.* 2019;21(4):547–557. doi:10.1093/neuonc/noy191.
 11. Mak DY, Laperriere N, Ramaswamy V, *et al.*, Reevaluating surgery and reirradiation for locally recurrent pediatric ependymoma: a multi-institutional study. *Neuro Oncol Adv.* 2021;3(1):vdab158. doi:10.1093/noajnl/vdab158.
 12. Louis DN, Perry A, Wesseling P, *et al.*, The 2021 World Health Organization Classification of Tumors of the Central Nervous System: a summary. *Neuro Oncol.* 2021;23(8):1231–1251. doi:10.1093/neuonc/noab106.
 13. Ellison DW, Aldape KD, Capper D, *et al.*, cIMPACT-NOW Update 7: advancing toward a molecularly defined classification of ependymomas. *Brain Pathol.* 2020;30(5):863–866. doi:10.1111/bpa.12866.
 14. Pajtler KW, Witt H, Sill M, *et al.*, Molecular Classification of Ependymal Tumors across All CNS Compartments, Histopathological Grades, and Age Groups. *Cancer Cell.* 2015;27(5):728–743. doi:10.1016/j.ccell.2015.04.002.
 15. Arabzade A, Zhao Y, Varadharajan S, *et al.*, ZFTA-RELA Dictates Oncogenic Transcriptional Programs to Drive Aggressive Supratentorial Ependymoma. *Cancer Discov.* 2021;11(9):2200–2215. doi:10.1158/2159-8290.CD-20-1066.
 16. Mack SC, Witt H, Piro RM, *et al.*, Epigenomic alterations define lethal subgroups of ependymoma. *Nature.* 2014;506(7489):445–450. doi:10.1038/nature13108.
 17. Upadhyaya SA, Robinson GW, Onar-Thomas A, *et al.*, Molecular grouping and outcomes of young children with newly diagnosed ependymoma treated on the multi-institutional SJYC07 trial. *Neuro Oncol.* 2019;21(10):1319–1330. doi:10.1093/neuonc/noz069.
 18. Larrew T, Saway BF, Lowe SR, Olar A. Molecular Classification and Therapeutic Targets in Ependymoma. *Cancers (Basel).* 2021;13(24):6218. doi:10.3390/cancers13246218.