Papillary Tumor of the Pineal Region in Children: Presentation of a Case and Comprehensive Literature Review

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Key words
- Children
- Immunohistochemistry
- Microneurosurgery
- Multidisciplinary management
- Papillary tumor of the pineal region
- Pineal region lesions
- Radiochemotherapy

Abbreviations and Acronyms
EMA: Epithelial membrane antigen
GFAP: Glial fibrillary acidic protein
PTEN: Phosphatase and tensin homolog
PTPR: Papillary tumor of the pineal region
WHO: World Health Organization

BACKGROUND: Papillary tumor of the pineal region (PTPR) is a rare grade II-III pineal lesion with peculiar histological and immunohistochemical features. These tumors mostly occur in adults, only rarely in children, with 19 cases reported up to now.

CASE DESCRIPTION: We present a 3-year-old boy who underwent reoperation for a recurrent PTPR (grade II). Gross total resection of the lesion through an occipital interhemispheric approach with the patient in a sitting position was followed by adjuvant radiotherapy and chemotherapy. Histological examination revealed tumor progression (grade III) and an MIB-1 proliferation index >25%. The patient continues to do well with no evidence of recurrence more than 3 years following surgery. A comprehensive literature review regarding the PTPR, including the current management in children, is reported.

CONCLUSIONS: PTPRs are extremely rare in children, and immunohistochemistry is needed to differentiate them from other pineal tumors. These tumors show a high rate of recurrence, and a multidisciplinary management approach (microsurgical resection followed by radiotherapy and/or chemotherapy) can help achieve a favorable outcome.

INTRODUCTION

Papillary tumor of the pineal region (PTPR) is a new entity introduced in the 2007 World Health Organization (WHO) nomenclature to describe a rare grade II-III pineal lesion with specific histological and immunohistochemical features. These tumors occur mostly in adults and are extremely rare in children.1-3

Herein we report the case of a 3-year-old boy who initially underwent surgery abroad for acute hydrocephalus due to a PTPR and was subsequently admitted to our department for a tumor recurrence a few months after the initial surgery.

We describe the multidisciplinary management of this patient, who exhibited a good response after gross total resection of the lesion and adjuvant radiotherapy and chemotherapy, with no recurrence after 3 years. We also present a comprehensive literature review of case reports of PTPR in children while describing the current management of this new entity this population.

CASE PRESENTATION

A three-year-old boy with a grade II PTPR was admitted to our department for reevaluation. Nine months earlier, he had presented with acute hydrocephalus and had undergone subtotal resection of the lesion abroad. Follow-up brain magnetic resonance imaging (MRI) revealed the persistence of a giant heterogeneously enhancing pineal region lesion with a small cystic component (Figure 1). Ventriculomegaly was also present. The patient demonstrated no neurologic deficits.

Gross total tumor resection was performed via an occipital interhemispheric approach with the patient in a sitting position (Figure 1). The postoperative course was uneventful.

Based on the operative video analysis, the following microsurgical aspects are highlighted:

- After a left occipital craniotomy, the dura was opened under microscopy based on the superior longitudinal sinus.
- Strong dural retraction with Vicryl stitches along the opening provided a hemostasis of the epidural space.
- Cerebrospinal fluid was released from the posterior interhemispheric cistern via the interhemispheric approach.
- After careful access, the tumor was recognized, and under high magnification, tissue samples were obtained for immediate histological studies.
- Internal debulking of the tumor was performed using ring forceps and long bipolar forceps.
Small vessels on the surface of the tumor were coagulated and cut. After careful dissection and devascularization of the lesion, the tumor was gently extracted using long ring microforceps in the right hand with a thumb-regulated suction tube in the left hand. The tumor was shrunk with bipolar coagulation, and piecemeal reduction of the tumor was performed. Water dissection was used to separate deep borders of the lesion from the surrounding tissue, and continuous irrigation was provided to maintain a clean surgical field. The final steps included careful detachment of tumor remnants from the inferior sagittal sinus and meticulous hemostasis of the surgical site. The postsurgical histological diagnosis was a grade III PTPR. On immunohistochemistry analysis, the lesion was positive for pancytokeratins (CK5, CK6, CK8, and CK18), vimentin, microtubule-associated protein 2, St00 protein, integrase interactor 1, CD99, transthyretin, CD56, epithelial membrane antigen (EMA; focal positivity), and synaptophysin (weak focal positivity). On the other hand, the lesion was negative for neurofilament protein, glial fibrillary acidic protein (GFAP), and chromogranin A (Figure 2).

The MIB-1 proliferation index was >25%, and the mitosis-specific marker phosphohistone-H3 was measured at 15 mitoses/mm². Compared with the histological findings from the first surgery, this tumor recurrence had more necrosis, more mitosis, and a higher MIB-1 proliferation index.

At 4 weeks after the surgery, the patient received focal fractionated radiotherapy to the pineal tumor bed. A total dose of 54 Gy was divided in daily doses of 1.8 Gy. In February 2015, the patient started chemotherapy based on an ependymoma protocol of cisplatin-cyclophosphamide-vincristine-etoposide delivered in 4 intravenous cycles, each lasting 21 days: 1) days 1, 8, and 15 for the first 3 cycles: vincristine 1.5 mg/m²; 2) days 1, 2, and 3: etoposide 100 mg/m²; 3) day 1, cisplatin 100 mg/m²; and 4) days 2 and 3: cyclophosphamide 1000 mg/m². The cisplatin dose had to be reduced from 100 mg/m² to 80 mg/m² because the patient had only 1 kidney due to a congenital malformation. At
more than 3 years after surgery, the patient continues to do well clinically, with no evidence of developmental delay and no recurrence (Figure 1).

**DISCUSSION AND LITERATURE REVIEW**

PTPR is a grade II-III pineal lesion introduced in the 2007 WHO nomenclature, with no major changes in the last 2016 WHO classification of brain tumors. According to the French Register of pineal tumors, true pineal tumors include pineal parenchymal tumors (27%), germ cell tumors (27%), gliomas (17%), and papillary tumors (8%), and pineal parenchymal tumors comprise pineocytomas (13%), pineal parenchymal tumors with intermediary differentiation (66%), and pineoblastomas (21%).

The first pineal tumor with a papillary aspect, reported as a papillary pineocytoma, was described by Trojanowski et al. in 1982. In 2003, Jouvet et al. introduced the term “PTPR.” Other pineal region tumors with expression of papillary features include ependymomas, choroid plexus tumors, papillary meningiomas, germ cell tumors, and papillary metastatic carcinomas. It is currently thought that PTPRs may derive from the subcommissural organ; thus, PTPRs, as well as the ependymal cells arising from the subcommissural organ itself, highly express CK18.

**Histology**

PTPRs are tumors characterized by an epithelial-like growth pattern in which vessels are covered by a layer of tumor cells forming perivascular pseudorosettes. Light microscopy shows a papillary architecture, with vascular connective tissue composed of several layers of large cuboidal or columnar epithelial-like growth pattern cells. The cell cytoplasm is clear and sometimes vacuolated. Nuclei are small and rounded. Mitotic figures are rare, and areas of tumor necrosis are very frequent.

Histology was positive for pancytokeratins, cytokeratin 18, S100 protein, and CD56 and negative for glial fibrillary acidic protein.

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**Figure 2.** Photomicrographs of surgical specimens. (A) Hematoxylin and eosin staining showing an epithelial-like growth pattern with vessels covered by a layer of tumor cells forming perivascular pseudorosettes. (B) Some necrotic areas were present. (C–G) Immunohistochemistry was positive for pancytokeratins, cytokeratin 18, S100 protein, and CD56 and negative for glial fibrillary acidic protein.
Immunohistochemistry
Cytokeratin KL1 and CKx8 are constantly expressed by PTPRs. PS100, vimentin, and neuron-specific enolase are frequently positive as well. Transthyretin, synaptophysin, and chromogranin immunolabeling are inconsistently positive. Tumor cells do not express GFAP or EMA, but GFAP expression can be recognized in the perivascular areas of the tumor.

Immunolabeling for antineuronal cell adhesion molecule and Nestin is frequently positive, but immunolabeling for anti-NF, anti-antigen S, anti-tau protein, anti-α-fetoprotein, and anti-placental alkaline phosphatase antibodies is negative.

Some studies have suggested that phosphatase and tensin homolog (PTEN) mutations and activation of the PI3K/Akt/mTOR signaling pathway may play roles in the biology of PTPR, thus opening the possibility of using PI3K/Akt/mTOR inhibitors in therapy for patients with PTPRs.

Studies in serum and cerebrospinal fluid were negative for the tumor markers α-fetoprotein and human chorionic gonadotropin.

Genetics
Regarding chromosomal alterations, losses of chromosome 10 were very frequent in different studies. Losses of chromosomes 3, 14, 22, and X also have been reported, as have gains of chromosomes 8, 9, and 12. Other chromosomal alterations include a homozygous PTEN deletion and 2 point mutations in exon 7 of PTEN (G251D and Q261stop).

Fève-Montange et al. reported that PTPRs show high expression of SPDEF, KRT18, and genes encoding proteins reported to be expressed in the subcommissural organ, such as ZFH4, RFX3, transthyretin, and CGBP.

Imaging
On MRJ, Chang et al. reported an intrinsic T2 hyperintensity centered on the posterior commissure, associated with T2 hyperintensity and gadolinium enhancement as a regular presentation in 4 PTPRs. However, fat content related to teratomas, as well as melanin, calcification, and extracellular methemoglobin (usually seen in melanotic tumors), and hemorrhagic metastases, choriocarcinomas, or teratomas, also must be excluded.

In contrast, other authors have reported a heterogeneous mass isointense on T1-weighted MRI.

Biological Behavior of PTPRs
PTPR grading and prognosis remain unclear, and reports of cases with long survival contrast with cases of local tumor recurrence. Histological grading of PTPRs correspond to WHO grade II or III.

Variables related to decreased progression-free survival include >3 mitoses per 10 high-power field, or a Ki-67 proliferation index >10%. Some authors have identified the isocitrate dehydrogenase 1 and 2 mutations in PTPR cells as a predictor of wild-type genotypes, as has been described in gliomas.

Differential Diagnosis
Regarding the differential diagnosis, as mentioned above, different tumors present with papillary architecture. However, the 2 main differential diagnoses are papillary ependymomas and choroid plexus tumors. Choroid plexus tumors share a comparable immunohistochemical profile with PTPRs, but with a different morphological appearance. On the other hand, ependymomas show a similar morphological appearance with differing antigenic expression. Choroid plexus tumors have an exclusively papillary architecture lined by a single cell layer without the massive component, and unlike in PTPRs, areas of necrosis are extremely rare. Choroid plexus carcinomas are well differentiated and with a greater degree of aplasia. Regarding the immunohistochemical analysis, potassium inwardly rectifying channel Kir 7.1 and stanniocalcin-1 are expressed only by choroid plexus tumors. Ependymomas show constant expression of EMA and GFAP, with no expression of cytokeratin KL1. Finally, only papillary tumors express microtubule-associated protein 2.

In contrast to PTPRs, papillary meningiomas show dense membrane expression of EMA. Vimentin and protein S100 are expressed by papillary meningiomas in 40% of cases. Papillary tumors of the pineal parenchyma, such as papillary pineocytomas, exhibit extensive expression of synaptophysin and antigen S, whereas cytokeratins and vimentin are not expressed.

DNA methylation profiling using Illumina 450k arrays reliably distinguished PTPRs from ependymomas and pineal parenchymal tumors of intermediate differentiation. The patients with PTPRs with greater global methylation had a tendency toward shorter progression-free survival.

The overexpressed SPDEF gene, known to be present in the rodent subcommissural organ, has significant expression in PTPR compared with ependymal tumors, choroid plexus tumors, and samples of other central nervous system tumor entities. Some papillary tumors of the midline, such as papillary thyroid carcinomas and papillary craniopharyngiomas, conceal BRAF-V600E mutations; however, PTPR demonstrated negativity for BRAF-V600E.

Management
In a multicentric retrospective study of 31 patients by Fève-Montange et al., gross total resection was the only factor that tended to have a significant positive effect on disease progression. A complete open resection was achieved in 21 cases and, after heterogeneous schemes of radiotherapy after complete (9) or incomplete (6) resection, 21 patients presented local (19), local and spinal (1), or only spinal (1) progression in a mean follow-up of 4.2 years (range, 0.2–16.5 years). The overall survival was 73% at 5 years and 58% at 10 years.

Regarding to the radiotherapy, based on the aforementioned study, this tumor appears to have a high potential for local recurrence during the 5 years after the initial surgery, suggesting the need for tumor bed boost radiotherapy after surgical resection. However, no strong evidence is available. On the other hand, spinal dissemination seems to be rare.

Radiotherapy may consist of craniospinal irradiation with a boost to the primary site, whole-brain radiotherapy with a boost to the primary site, focal irradiation of the pineal area only, or radiosurgery. In a study published by Fauchon et al., the median pineal dose in 22 of the 26 irradiated cases was 54 Gy (95% confidence interval, 12.0–60.0 Gy). Despite relatively high cumulative doses (>100 Gy in 3 cases), only 2 cases presented with irradiation-related side
<table>
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<tr>
<th>Author</th>
<th>Age (years)/Sex</th>
<th>Size (mm)</th>
<th>Surgical Treatment</th>
<th>Histopathology</th>
<th>Radiotherapy</th>
<th>Chemotherapy</th>
<th>Follow up (Months)</th>
<th>First Recurrence and Treatment</th>
<th>Second Recurrence and Treatment</th>
<th>Third Recurrence and Treatment</th>
<th>Fourth Recurrence</th>
<th>Final status</th>
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<tr>
<td>Buffenoir et al., 2008</td>
<td>13/Male</td>
<td>31</td>
<td>ETV + B, GTR</td>
<td>MIB-1: 2.6%</td>
<td>Yes, 50 Gy</td>
<td>Yes, ACNU</td>
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<td>11/Male</td>
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<td>PR, VPS, GTR (3 months later)</td>
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<td>Yes, 50.4 Gy</td>
<td>Yes, ACNU</td>
<td>180</td>
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<td>NAI</td>
<td>NAI</td>
<td>NAI</td>
<td>61</td>
<td>LR at 21 months: GTR + RT</td>
<td>VR + SR: 9 cycles of GEMOX</td>
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<td>Hua et al., 2015</td>
<td>10/Female</td>
<td>20</td>
<td>GTR</td>
<td>Ki-67: ~5%</td>
<td>Yes</td>
<td></td>
<td>15</td>
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<td>Li et al., 2011</td>
<td>1.25/Male</td>
<td>10</td>
<td>ETV, B (TFCA), B + PR (TFCA), ETV, VPS</td>
<td>MIB-1: 5–8%; Mt: 3/10 HPF</td>
<td>Yes, 4 cycles of VMEOCyCi</td>
<td>15</td>
<td>Local regrowth (after 2 cycles of CMT): PR + CMT + PBRT (6 weeks)</td>
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<td>Alive, left oculomotor nerve deficit, stable disease</td>
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<td>Abela et al., 2013</td>
<td>3/Female</td>
<td>35</td>
<td>GTR (SCIT)</td>
<td>Ki-67: 10–15%; Mt: 4–6/10 HPF</td>
<td>Yes, 4 cycles of VMEOCyCi</td>
<td>39</td>
<td>LR at 3 year: PR + PBRT 54 Gy</td>
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<td></td>
<td>Alive, Parinaud’s syndrome, stable disease</td>
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<td>7/Female</td>
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<td>GTR</td>
<td>Yes, 54 Gy</td>
<td>Yes</td>
<td>Yes</td>
<td>95</td>
<td>No</td>
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<td>30</td>
<td>B, GTR</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>3</td>
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<td>23</td>
<td>GTR</td>
<td>Ki-67: 6%; Mt: 1/10 HPF</td>
<td>Yes, 50 Gy</td>
<td>Yes, ACNU</td>
<td>12</td>
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<td>Age</td>
<td>Event</td>
<td>Location</td>
<td>Mitotic Activity</td>
<td>Treatment</td>
<td>Follow-up</td>
<td>Outcome</td>
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<td>10/Female</td>
<td>Ki-67: 3%; Mi: &lt;1/10 HPF</td>
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<td>NAI</td>
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<tr>
<td>11/Female</td>
<td>Ki-67: 19.6%; Mi: 7/10 HPF</td>
<td>NAI</td>
<td>NAI</td>
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<tr>
<td>Iacoangeli et al., 2017</td>
<td>10/Male</td>
<td>24 recurrence</td>
<td>GTR (SCIT) + TEV, VPS</td>
<td>MIB-1: 5%</td>
<td>Yes, 54 Gy</td>
<td>120 LR at 3 years: GTR (microscopic + endoscopic technique)</td>
<td>Alive</td>
<td></td>
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<tr>
<td>Gutenberg et al., 2011</td>
<td>13/Male</td>
<td>50</td>
<td>VPS, GTR (OC)</td>
<td>Low mitotic activity</td>
<td>Yes, craniospinal</td>
<td>180 LR at 60 months: PR + SRS (20Gy)</td>
<td>Alive, symptom-free</td>
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<td>Marcel et al., 2007</td>
<td>10/Female</td>
<td>~ 20–30</td>
<td>VPS, GTR (SCIT)</td>
<td>MIB: 10/10 HPF</td>
<td>Yes</td>
<td>Yes</td>
<td>72 No</td>
<td>Alive, symptom-free</td>
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<td>Present case</td>
<td>2/Male</td>
<td>PR (SOA)</td>
<td>WHO grade II, LR: MIB-1 &gt;25%, 15 mitosis/mm²</td>
<td>40 Yes, LR at 10 months: GTR (OIH) + RT: 54 Gy + CMT: CiCyVE</td>
<td>Alive, symptom-free</td>
<td></td>
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**Legend:**
- **ACNU:** nimustine
- **B:** biopsy
- **Ca:** carboplatin
- **Ci:** cisplatin
- **CMT:** chemotherapy
- **Cy:** cyclophosphamide
- **E:** etoposide
- **ETV:** endoscopic third ventriculostomy
- **GEMOX:** gemcitabine—oxaliplatine
- **GKRT:** gamma knife radiation therapy
- **GTR:** gross-total resection
- **HPF:** high-power field
- **LR:** local recurrence
- **M:** methotrexate
- **Mi:** mitosis
- **NA:** not available
- **OC:** occipital craniotomy
- **OIH:** occipital interhemispheric approach
- **PBRT:** proton-beam radiation therapy
- **PR:** partial resection
- **RT:** radiotherapy
- **S:** surgery
- **SCIT:** supracerebellar infratentorial approach
- **SOTA:** suboccipital transtentorial approach
- **SOA:** suboccipital approach
- **SRS:** stereotactic radiosurgery
- **TFCA:** transfrontal transchoroidal approach
- **V:** vincristine
- **VPS:** ventriculo-peritoneal shunt
- **VR:** ventricular recurrence
- **WHO:** World Health Organization

*These cases were published initially by Fèvre-Montange et al. and later updated by Fauchon et al.*

**Notes:**
- One case was also reported by Jeruc and Popovic with no available information in the literature.
- Initially reported as an anaplastic pleuropapilloma (WHO grade III).
- Reported as a papillary pineocytoma.
effects: a thalamic radionecrosis associated with diplopia and hypersomnina, and a thalamotectal radionecrosis associated with motor deficiency and Parinaud syndrome.27

Some authors have reported favorable outcomes after biopsy procedures followed by radiotherapy. In a case described by Patel et al.,24 an endoscopic third ventriculostomy with a simultaneous endoscopic biopsy followed by postoperative radiotherapy (50.4 Gy) resulted in complete regression of the tumor with no evidence of recurrence at 25 months. Similarly, Riis et al.25 described a case of PTPR treated with stereotactic radiosurgery in a gamma knife unit after stereotactic biopsy of the tumor. At 5 years after treatment with a dose of 12 Gy on the 50% isodose, the tumor was still shrinking.25

Ishida et al. studied the safety and efficacy of stereotactic 125-iiodine brachytherapy for the treatment of PTPRs. Complete (100%) local tumor control was achieved with a median follow-up of >4 years. No significant clinical or radiologic side effects of 125-iiodine brachytherapy were detected during the follow-up period, and all symptoms improved significantly.20,26

Chemotherapy has been proposed in specific cases of rapid spinal dissemination, first-line radiotherapy-based treatment, and local recurrences; however, the evidence supporting this modality remains weak.21 Adjuvant chemotherapy is based mainly on cisplatinum and etoposide protocols, including carboplatin-VP16-vincristine, carboplatin plus either etoposide or vincristine, temozolomide, and ACNU (3-[(4-amino-2-methyl-5-pyrimidinyl)-1-methyl]-1-(chloroethyl)-1-nitrosourea).21,23,25-27,29 Bevacizumab, a humanized monoclonal antibody against vascular endothelial growth factor, which has demonstrated activity in ependymoma, should be considered for inoperable recurrent PTPRs and in those amenable/responsive to radiation or standard cytotoxic treatments.20,31

PTPRs in Children

Regarding the management of PTPRs in children, children account for only 16%-19% of cases, the literature is scarce.11,22 Table 1 lists the published cases.10-12,22,23,32-37 We found 19 cases in children age <17 years.

Although some information was not available in this small cohort, we can draw some conclusions from our analysis of the 20 cases. No sex difference was found, and the mean tumor diameter was 30 mm. In 3 cases, information on follow-up was unavailable. In the remaining 17 cases, the mean duration of follow-up was 67.5 months (range, 3-180 months). Eight of these 17 patients (47%) experienced tumor recurrence or regrowth during the follow-up. The mean time of the first recurrence was 34.5 months (range, 10-60 months). At the last follow-up, 15 of the 17 patients (88%) were alive and symptom-free or with controlled disease, 1 patient had progressive disease, and 1 patient died at 61 months after starting treatment. A gross total resection during the course of the disease was performed in 15 of the 17 patients (88%), with a partial resection followed by radiotherapy and chemotherapy was performed in the remaining 2 patients (12%), who demonstrated stable disease after 15 and 21 months. Only 3 of the 15 patients (20%) who underwent gross total resection did not receive complementary therapy during the course of the disease. Those 3 patients showed no recurrence at 3, 12, and 15 months of follow-up.10-12,22,23,32-37

Summarizing our results, follow-up information was available for 17 of the 20 pediatric patients reported in the literature, and gross total resection was achieved in 15 of these patients during the course of the disease. Only 1 of the 2 patients with partial resection had nonrecurrent stable disease. Four of the 8 patients who presented with local recurrence/regrowth during follow-up had a second recurrence (3 local recurrences and 1 spinal and ventricular recurrence). Three patients had 3 recurrences (a repeated spinal recurrence, a local recurrence, and another ventricular recurrence). One patient had 4 local recurrences. The patient with spinal disease died.10-12,21,23,32-37

Compared with the epidemiology in the general population, where 68% of PTPRs occurred at a mean follow-up of 4.2 years (with an overall survival of 73% at 5 years and 58% at 10 years), in the pediatric population, only 47% of PTPRs recurred at a mean follow-up of 6.5 years.11 The survival rate of the entire pediatric cohort was 94%, with only 1 death after 5 years after starting the treatment. However, only 40% of the children had follow-up longer than 5 years.11 This difference may be explained by the fact that a gross total resection was achieved in 88.24% of the pediatric patients, compared with only 68% of the adults. Another reason could be the different (i.e., more aggressive and infiltrative) biological behavior of the tumor in adults. In this regard, measurements of the DNA methylation, and determination of the isocitrate dehydrogenase 1 and 2 mutations in PTPR cells instead of the well-known mitotic index and Ki-67 proliferation index, could be important tools for evaluating the progression-free survival rate. Moreover, future perspectives on genetic features will be essential to determine the malignancy grade of the lesion.14,19,20

Surgery was performed using different approaches, most frequently via the occipital interhemispheric, suboccipital supracerebellar, transchoroidal, and endoscopic translamellar terminalis routes.10-12,22,23,32-37 Regarding the posterior routes to the pineal regions, the sitting position may offer several advantages over the horizontal position, and several protocols may be effectively used in the clinical setting to prevent major complications.38-45 Biopsy through an endoscopic approach, associated with a third ventriculostomy, followed by radiotherapy was another option. Irrespective of the approach selected, skillful, clean micro-neurosurgery preserving the normal anatomy is imperative during operations involving the pineal region.44-46

Common radiotherapy schemes included external beam radiotherapy and proton beam radiotherapy with doses of 50-54 Gy as a part of the initial treatment and treatment of recurrences.10-12,22,23,32-37 A local recurrence in a 13-year-old boy (who initially underwent a gross total resection, craniospinal radiation, and chemotherapy) was controlled by partial resection followed by stereotactic radiosurgery (20 Gy). The patient subsequently underwent 2 more local resections that were managed with stereotactic radiosurgery alone (22 and 20 Gy). At a 180-month follow-up, the patient was working as a computer scientist.35

The main schemes of chemotherapy were based on ACNU, carboplatin-VP16-vincristine, 9 cycles of gemcitabine-oxaliplatin as second line chemotherapy.
for the case with the spinal recurrence, and cisplatin-cyclophosphamide-vincristine-etoposide in our case.19-20,22,23,32-37

CONCLUSIONS
Even though PTPRs in children have a high rate of recurrence during the first 5 years, good control of the disease is possible. Radiotherapy and chemotherapy are important tools in initial management, as well as in management of recurrences after gross total resection. Stereotactic radiosurgery may be an important tool for the management of local tumor recurrences, with patients demonstrating good cognitive function at long-term follow-up.

REFERENCES


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