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CASE REPORT

Pediatric meningiomas: a report of 5 cases and review of literature

Sukwoo Hong [1] · Kenichi Usami [1] · Daisuke Hirokawa [1] · Hideki Ogiwara [1,2]

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Abstract

Purpose The purpose of this paper is to provide novel insight into the rare pediatric meningiomas.

Methods We retrospectively analyzed pediatric surgical cases of meningioma during 2002 to 2017 in our institution. The preoperative, intraoperative, and the postoperative status were collected to find any unique features that has not reported in the past.

Results Nine surgeries out of 5 patients were identified. The mean age was 7 years old (range 1–14 years old). Four patients were females. The mean tumor diameter was 52 mm (range 23–81 mm). The tumor locations were optic nerve sheath, Sylvian fissure, parasagittal, trigone of the lateral ventricle, and cerebellopontine angle. The Sylvian fissure meningioma without dural attachment (MWODA) was found in a 15-month-old female. A relapsed parasagittal meningioma showed regression in histological grade and residual tumor demonstrated spontaneous regression. In the initial surgeries, Simpson grade 1 resection was achieved in 2 cases. The pathological diagnoses were 1 meningothelial, 1 metaplastic, 2 atypical, and 1 clear cell meningiomas. The mean postoperative follow-up period was 71 months. Three patients experienced recurrence of the tumor. At the latest follow-up, all patients were free of radiological tumor recurrence or regrowth with a mean follow-up of 4 years (range 1–6.9 years). All patients were in the modified Rankin scale of 0–1.

Conclusions MWODA is not considered to be rare in pediatric meningioma and should be included in the differential diagnosis. We presented a histologically regressed relapsed meningioma, which spontaneously regressed after subtotal resection. In the case of recurrent meningioma, surgical resection and adjuvant radiation therapy could be effective for long-term control of the tumor.

Keywords Meningioma · Children · Spontaneous regression · Dural attachment

Introduction

Pediatric meningiomas are rare accounting for about 0.4–4% of all brain tumors in children, and they conform unique characteristics compared to adults [1–8]. Meningiomas in children tend to be male-predominant, cystic, and intraventricular, and are likely to have no dural attachment. We performed institutional retrospective analysis of meningiomas to give additional insight to this rare entity.

✉ Hideki Ogiwara
hideki_o@d5.dion.ne.jp

1 Division of Neurosurgery, National Center for Child Health and Development, Tokyo, Japan

2 Setagaya-ku, Japan

Methods

We retrospectively analyzed pediatric meningiomas diagnosed in our facility from 2002 to 2017. For each case of meningioma, the data was collected from medical charts, including age, chief complaints, tumor sites, the largest tumor diameter, intraoperative estimated blood loss (EBL), perioperative transfusion, Simpson grade, histological subtype, postoperative complications, clinically symptomatic tumor recurrences (relapses), and the latest modified Rankin scale (mRS). Exclusion criterion was those 18 years old or older at initial presentation.

Results

There were 391 patients with brain tumors and 556 surgeries performed during 2002 to 2017. Eleven surgical cases of 7 patients were identified as meningioma resection. Two patients were excluded due to age older than 18 years old. As a result, 9 surgical cases in 5 patients were included. Their clinical courses were summarized in Table 1. The meningioma accounted for 1.3% of all pediatric brain tumors in our institution. There were 1 male and 4 females and their mean age at diagnosis was 7.2 years old (range 1–14 years old). Neither had history of radiotherapy to the central nervous system nor association with neurofibromatosis. The mean size of the tumor was 52 mm (range 23–81 mm). The tumor locations are the optic nerve sheath, Sylvian fissure, parasagittal, trigone of the lateral ventricle, and cerebellopontine angle. In the initial surgery, Simpson grade 1 resection was achieved in 2 cases, which are located in the Sylvian fissure and the trigone of the lateral ventricle. Simpson grade 3 was achieved in parasagittal meningioma. Simpson grade 4 was achieved in 2 cases, which is located in the cerebellopontine angle (CPA) and optic nerve sheath. The mean EBL was 230 ml. The histopathological diagnoses were 1 meningothelial in optic nerve sheath, 1 metaplastic in the left atrium, 2 atypical in Sylvian and parasagittal, and 1 clear cell in CPA meningioma. The mean postoperative follow-up period was 71 months.

Three patients experienced recurrence of the tumor. Surgical resection was performed in all cases. Simpson grades 1, 3, and 4 were achieved for each. Adjuvant radiation therapy for residual tumor was given in one case. We did not carry out genetic analysis as none had any family history of tumor predisposition syndrome or developed new lesions during the follow-up period.

Illustrative cases

Pt no. 4

A 15-month-old female was referred to our facility for left temporal region mass. She had recent worsening of the complex partial seizure (CPS) which started when she was 10 months old. Magnetic resonance imaging (MRI) revealed a left temporal mass of 3.6-cm diameter (Fig. 1). Computed tomography (CT) showed no areas of calcification. Neurological examination showed no apparent abnormality and her CPS was controlled with valproate. Our preoperative differential diagnoses were embryonal tumors, dysembryoplastic neuroepithelial tumor, high-grade glioma, or meningioma. We decided to perform surgical resection by left frontotemporal craniotomy. The surgical corridor was made by 2.5-cm corticotomy from the middle to inferior temporal gyrus. The tumor resided in the deep Sylvian fissure and there was no attachment to the dura or infiltration to the surrounding cortex and lateral ventricle. Gross total resection was achieved (Fig. 2). The estimated intraoperative blood loss was 30 ml. The postoperative course was uneventful and there has been no report of seizure since the surgery. The

Table 1 The summary of patients. None underwent preoperative angiogram, had history of radiation therapy to the central nervous system, or associated with neurofibromatosis

Pt no.	Age (years), sex	Chief complaint	Site	Largest diameter (mm)	EBL (ml)	Transfusion (ml)	Simpson grade	Histological subtype/WHO grade	Cx	Recurrence	Latest mRS	PFS after the last therapy (years)
1	8, F	Strabismus, hearing deficits	R CPA–MF	79	300	290	4	Clear cell/II	CN palsies[a]	Y	1	2.1 (after adjuvant XRT)
2	1, F	Sz	L occipital parasagittal	39	200	220	3	Atypical[b]/II	N	Y	0	6.8*
3	14, F	Anorexia, amenorrhea	L trigone	81 (including cyst)	600	700	1	Metaplastic/I	Transient Sz	Y	0	5.7*
4	1, F	CPS	L Sylvian	37	30	50	1	Atypical/II	N	N	0	1*
5	12, M	VFD	R ON sheath	23	35	0	4	Meningothelial/I	N	N	1	2.8

Pt no patient number, *EBL* estimated blood loss, *Cx* complications, *mRS* modified Rankin scale, *PFS* progression-free survival, *M* male, *F* female, *R* right, *L* left, *CPS* complex partial seizure, *VFD* visual field deficits, *CPA* cerebellopontine angle, *MF* middle fossa, *ON* optic nerve, *Sz* seizure, *Y* yes, *N* no, *WHO* World Health Organization

[a] R CNVI palsy, R facial paresis of House and Brackmann grade 4, and R vocal cord paresis

[b] The 2nd surgical specimen of relapsed tumor showed fibrous meningioma

*Indicates cases that have achieved tumor-free states

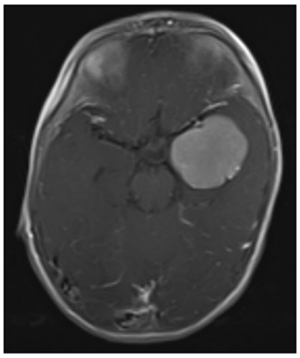

Fig. 1 Preoperative gadolinium–enhanced axial MRI showed left intra-Sylvian homogeneously enhancing mass

histopathological examination revealed spindle cells forming whorls with focal area of sheeting formation and focal necrosis. Tumor cells were positive for epithelial membrane antigen and S-100, and negative for glial fibrillary acidic protein and synaptophysin. MIB-1 index was about 10%. Atypical meningioma was diagnosed. She had been stable without recurrence of the tumor for 1 year.

Pt no. 2

A 16-month-old female presented with repeated episodes of seizure. Her first seizure occurred when she was 12 months old, which was observed as febrile seizure. Four months later, she had another seizure attack, when MRI was taken, which showed a mass of 3.5 cm × 3.6cm × 3.9cm in the left occipital parasagittal lesion attached to the superior sagittal sinus (SSS) (Fig. 3). Surgical resection of Simpson grade 3 was performed. The portion of the tumor attached tightly to the SSS was left. The pathological examination revealed spindle cells, with 4 or more mitosis and prominent nucleoli compatible with grade 2 atypical meningioma (Fig. 3c/d). MIB-1 index was 5%. Postoperative MRI showed enlarging residual meningioma, which was observed as seizure was under control. Four years later, she presented with status epilepticus. MRI showed further enlargement of the residual meningioma. The tumor size was 3.2 cm × 2.5cm × 3.4cm (Fig. 4a). Simpson grade 3 resection was performed. The portion of the tumor which invaded into the SSS was left. Histopathological examination showed fibrous meningioma with little mitosis and no prominent nucleoli not meeting the criteria of atypical meningioma (Fig. 4d/e). MIB-1 index is about 3–5%. Immediate postoperative MRI showed small residual tumor adjacent to the SSS (Fig. 4b). Since histopathological grade was grade I, no adjuvant therapy was performed. Subsequent MRI showed gradual spontaneous regression of the tumor. The residual tumor completely disappeared after 6 years (Fig. 4c) and at the last follow-up of 7 years after the second surgery, MRI showed no evidence of tumor recurrence.

Discussion

To the best of our knowledge, we presented 3 rare findings of meningiomas in this series. First, we presented the infantile surgical case of atypical meningioma in the deep Sylvian fissure without dural attachment (MWODA). Second, we experienced the case of benign transformation at recurrence. Thirdly, residual tumor demonstrated a spontaneous regression.

The major differences between pediatric and adult meningiomas are larger size and less tolerance to intraoperative blood loss in pediatric populations [9–11]. Securing and coagulating the feeding vessels at an early phase is important to decrease blood loss. Internal decompression should be started after coagulating the feeding vessels. When feeding vessels are multiple and cannot be coagulated at an early phase of resection, transfusion should be started without delay. Also, biological characters may be different between pediatric and adult meningiomas. In our 2 cases of atypical meningioma, both has taken relatively good clinical course, no recurrence over 1 year after GTR in the case 4, and involution after subtotal resection in case 2. This potential biological difference should be elucidated by further genetic studies.

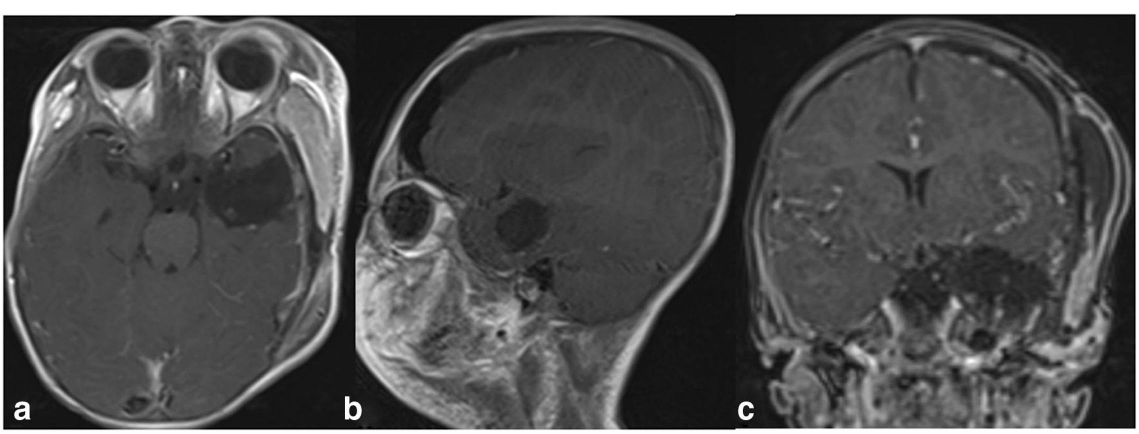

Fig. 2 Postoperative gadolinium–enhanced MRI showed no residual enhancing mass lesions. **a** Axial view. **b** Sagittal view. **c** Coronal view

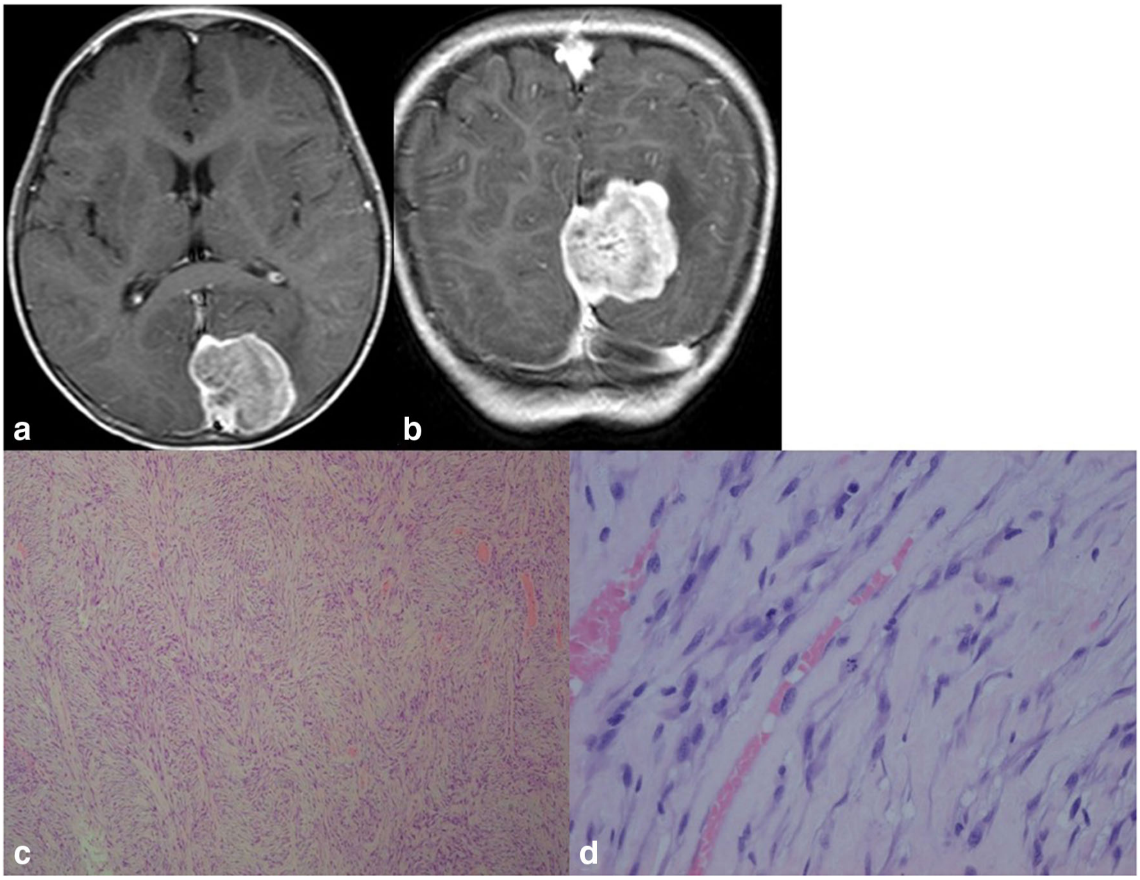

Fig. 3 Preoperative gadolinium–enhanced MRI showed left occipital enhancing mass attached to the SSS (**a**). Note the characteristic mushrooming mass suggestive of atypical meningioma on the coronal image (**b**). Pathology slide showing spindle cells (**c**), with 4 or more mitosis and prominent nucleoli (**d**) compatible with grade 2 atypical meningioma. Original magnification × 40 (**c**) and × 400 (**d**)

Meningioma without dural attachment

Meningioma in pediatric population is rare as opposed to adults, which accounts for 0.4–4.0% of all CNS tumors in this age group [1, 5, 7, 8]. In our facility, meningiomas accounted for 1.3% of all pediatric brain tumors consistent with the past literatures. There were several differences between meningioma of children and that of adults. In children, meningiomas show slight male predominance, more cystic, more intraventricular, and more tend to be absent from dural adhesions [2–4, 6, 8]. Meningioma without dural attachment (MWODA) is rare in adults. In children, MWODA accounts for 13–27.7% of the meningiomas [1, 2, 4–6, 12].

Since meningioma is thought to be arisen from arachnoid cap cells or meningothelial cells, theoretically, it could occur at any locations those cells are supposed to exist. As for the origin of MWODA, previous study reported it may arise from the arachnoid cap cells in the perivascular space, distant enough for the tumor to attach to the surrounding dura [4]. Location of MWODA in children in previous reports included cisterns (Sylvian fissure, CPA), ventricles (lateral, third, and fourth), and parenchyma (frontal lobe being most common), with intraventricle, pineal regions, and Sylvian fissure being the typical locations [1, 2, 9, 12–17]. MWODA tends to arise where many arachnoid membranes exist.

Because of its rarity, meningioma is often not included in preoperative differential diagnoses of pediatric brain tumors, especially when there is no radiological evidence of dural attachment. However, as meningioma is a highly vascular tumor, including MWODA in differential diagnosis may help surgeons better prepared to avoid excessive bleeding. The reason that we lost relatively low amount of blood (30 ml) in case 4 is considered that we coagulated the feeding vessels at an early phase of the surgery and performed en bloc resection with minimum internal decompression. Such strategy may be helpful for resection of these highly vascular tumors.

Histopathological regression in meningioma relapse

There have been no reports of regression in histopathological subtype in meningioma relapse. There were several reports about progression in histopathological grade in meningioma relapse [12, 18]. In our case, we observed histological grade regression from atypical meningioma to fibrous meningioma. According to the 2016 WHO classification, atypical meningioma is diagnosed if any of the following is present: (1) brain invasion, (2) mitotic

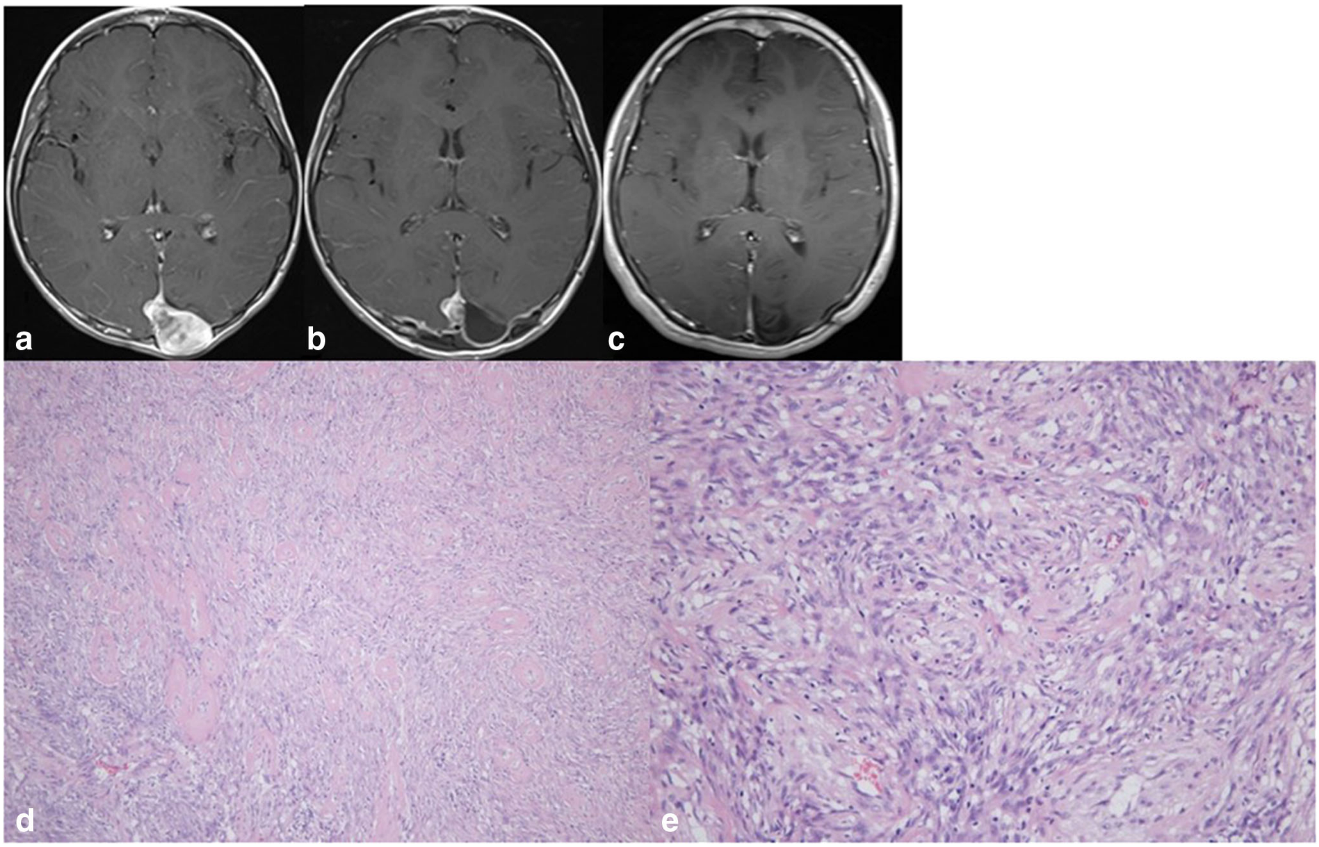

Fig. 4 Axial gadolinium–enhanced MRI just before the 2nd operation showing relapsed heterogeneously enhancing mass with no mushrooming pattern as before (**a**). The residual tumor of 12 mm in diameter attached to the SSS just after the 2nd operation (**b**) was followed annually for 6 years, when the mass spontaneously regressed (**c**). Pathology shows spindle cells forming whorls (**d**). There were areas of high cellularity but none showed mitotic figure of 4 or more (**e**) not meeting the criteria for atypical meningioma. Original magnification × 40 (**d**) and × 200 (**e**)

count of 4 or more, in addition to the 3 findings out of the 5 following criteria: (1) necrosis, (2) sheeting, (3) prominent nucleoli, (4) high cellularity, (5) small cells [19].

Technically, since the portion attached to the SSS was left, we cannot definitively say that the relapsed tumor was grade I fibrous meningioma. The tumor attached to the SSS might have contained grade II atypical meningioma. However, it is safe to say that our relapsed meningioma potentially regressed histopathologically.

Although the optimal treatment has not been established for recurrence of atypical meningioma, adjuvant XRT after resection is often performed in adults [18]. Since the grade regressed in our case, postoperative XRT was not performed and the patient has been free of recurrence for the past 6 years.

The reason for this regression may be that in the 1st operation, the tumor and the adjacent parenchyma was detached, and there was not enough time for the recurrent tumor to infiltrate the pia or have feeding vessels. Another possibility is that the pathological grade of atypical meningioma may not be necessarily applicable to pediatric populations. Although atypical meningioma is grade II, they may not behave so in children as bad as adults.

Spontaneous regression of meningioma

Although there have been several reports of reduction in size in meningioma by medications that modulate progesterone or estrogen receptors, few reports exist regarding spontaneous

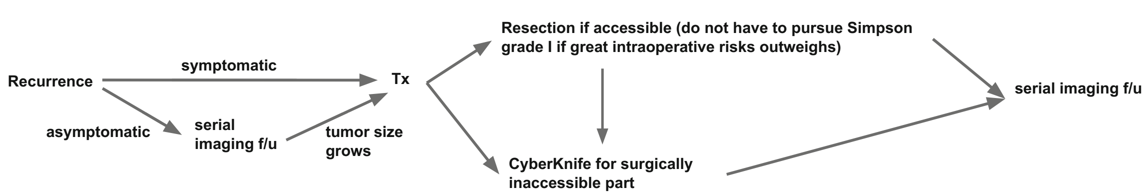

Fig. 5 Algorithm for recurrence or relapsed meningioma in children. If symptomatic, we should treat by surgical resection for accessible lesions and radiation for inaccessible lesions. We may not always have to pursue Simpson grade 1 resection despite the potential intraoperative risks. f/u, follow-up; Tx. treatment

Table 2 The summary of cases

Sex (male:female)	1:4
Mean age at diagnosis (years)	7.2 (1.3–14.5)
Mean of the largest tumor diameter (mm)	52 (23–81)
Mean of EBL (ml)	230
Mean of transfusion (ml)	190
WHO grades (I:II:III) of the initial surgical specimen	2:3:0
Postoperative mRS	0–1
Previous CNS XRT or association with NF	None

WHO World Health Organization, *CNS* central nervous system, *XRT* radiation therapy, *NF* neurofibromatosis

regression. Only 3 adult case reports exist as for the spontaneous regression [20, 21]. To the best of our knowledge, this is the first pediatric case of spontaneous regression of meningioma. The proposed mechanism of regression is mainly vascular event (either hemorrhage or infarct) and immune system activity [20]. The reason in our case may also be related to some vascular events in the microenvironment of the tumor. The postsurgical inflammatory changes also may contribute to a long-term process to the radiological disappearance of the tumor.

Treatment strategy for recurrent meningioma in children

In our series, functional outcome at the last follow-up was good with the mRS of 0–1 in all patients. So we propose the following treatment strategy (Fig. 5). If the recurrent or relapsed meningioma is symptomatic, we do not hesitate to do reoperation for surgically accessible lesions. Simpson grade 1 resection may not always be needed to gain the best outcome as exemplified by our patient number 2. Cyberknife surgery (CKS) may be effective for tumor control of surgically inaccessible parts of the tumor.

This algorithm is in line with previous reviews of meningioma except that none mentioned use of CKS as a radiation treatment [5, 22–32]. The results of the past case series are summarized in Table 2. Radiotherapy seems to be a viable option especially those with recurrent or higher-grade meningiomas (Table 3) [5, 24–32]. Although there have been few reports about CKS on the meningioma recurrence, 1 patient from a past report [33] as well as our patient number 1 did not suffer new-onset deficits after CKS. We may say CKS is a safe adjuvant treatment in addition to gamma knife. As for the degree of surgical resection, Li et al. found that narrow-based dural attachment and irregular tumor shape in the preoperative MRI as independent risk factors for recurrence after surgery [34]. We can use these preoperative imaging factors as a guide to how far to pursue resection intraoperatively as well as how often to do postoperative imaging follow-up.

Limitations

This case series' limitations are a small number of cases and retrospective nature. As it is difficult to gain enough meningioma cases in pediatric population, we need to do multicenter analysis to establish the nature of pediatric meningiomas as well as to verify the above-mentioned treatment strategy.

Conclusions

MWODA is not considered to be rare in pediatric meningioma. We presented the youngest case of MWODA. In the case of

Table 3 The summary of the past case series of pediatric intracranial meningiomas

Authors/year	Number of patients	Male:female ratio	WHO grade I:II–III	Management of residual or higher-grade tumors (resection was the treatment of choice in all series)
Present case/2019	5	1:4	2:3	Cyberknife surgery for residual higher-grade tumors
Ravindranath et al./2013	31	22:9	22:11	Radiation to recurrence or higher-grades
Santos et al./2012	15	9:6	11:4	Radiosurgery for small recurrent tumor in the orbit
Lakhdar et al./2010	21	13:8	13:8	Postoperative radiation to residuals and recurrence
Mehta et al./2009	18	11:7	16:2	Postoperative radiation to angioblastic and aggressive syncytial meningiomas
Menon et al./2009	38	20: 8	30:11	Radiation to residuals, but reoperation for benign partially excised lesions
Alexiou et al./2008	8	6:2	6:2	Gross total resection done for all cases with no recurrence
Liu et al./2008	12	7:5	12: 0	Postoperative radiation to residuals
Caroli et al./2006	27	20:7	24:3	Not described
Amirjamshidi et al./2000	24	13:11	23:1	Re-resection for recurrence; local radiation for higher-grades
Erdincler et al./1998	28	18:10	28:1	Chemoradiation to anaplastic meningioma; radiation to 3rd relapsed benign meningioma; postop radiation to residuals

WHO World Health Organization

recurrent meningioma, surgical resection and adjuvant radiation therapy could be effective for long-term control of the tumor.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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