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MR and CT findings of craniopharyngioma during and after radiation therapy

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Abstract Long-term changes in craniopharyngioma treated with radiation therapy (RT) were investigated by computed tomography (CT) and/or magnetic resonance (MR) imaging. Eight patients with craniopharyngioma were treated with incomplete resection or conservative surgical intervention followed by postoperative RT. The periods of tumor shrinkage were often long and varied (range: 6–68 months, mean: 29.1 months). Temporary enlargement of the solid component of a tumor usually occurs during RT and does not represent tumor progression. Cystic enlargement also occurs sometimes comparatively early after RT, and enlarged cysts often shrink with no treatment or with conservative treatment. These changes should be differentiated from tumor recurrence, with careful follow-up. After shrinkage, small solid or cystic nodules enhanced with contrast medium often remain. Long-term follow-up is necessary to differentiate uncontrolled tumors from controlled tumors with imaging modalities.

Keywords Craniopharyngioma · Radiation therapy · MRI · CT

Introduction

Craniopharyngioma is a benign intracranial tumor that frequently recurs locally after surgery alone. The recurrence rate is about 30%–50% even when complete resection is achieved [1, 2, 3, 4, 5, 6]. When craniopharyngioma is treated with incomplete resection and postoperative radiation therapy (RT), with precise planning based on magnetic resonance (MR) imaging and/or computed tomography (CT), recurrence rates are about 5% and severe complication rates are much lower than with complete resection [6, 7, 8]. The usefulness of RT for craniopharyngioma has been recognized, but tumor changes during and after RT on MR imaging and CT have not been clarified. To diagnose tumor recurrence after RT accurately, the course of this tumor during and after RT should be investigated.

Methods

From 1986 to 1996, eight patients (age range: 3–54 years, mean age: 37.0 years, male:female = 4:4) with pathologically proven craniopharyngioma were treated with partial/subtotal resection or cyst evacuation followed by postoperative RT in Yamagata University Hospital. Six of the eight were previously untreated cases, and the other two patients had recurrent tumors after complete resection or cyst evacuation without RT. They were followed up with MR imaging and/or CT. Follow-up times of all patients ranged from 24 to 158 months (median: 72 months).

Presurgical MR imaging and/or CT revealed entirely cystic lesions in three patients, entirely solid lesions in two patients, and mixed solid and cystic lesions in three patients. Tumor size ranged from 2.5 cm to 4.5 cm (mean: 3.5 cm). Four patients received partial/subtotal resection alone, three patients received partial/subtotal resection and insertion of Ommaya's tube, and one patient received cyst evacuation and insertion of Ommaya's tube (Table 1). The interval between surgical intervention and the initiation of RT ranged from 12 days to 68 days (median: 17.5 days). Radiation

Table 1. Patient characteristics and treatment results of incomplete resection followed by postoperative irradiation (*M* male, *F* female, *RT* radiation therapy, *OT* insertion of Ommaya's tube)

Age, gender	Tumor size and type	Surgical intervention	RT dose	Follow-up	Time of cystic enlargement after RT	Period of shrinkage	Size and type of the remnant component	Local recurrence
1[b] 32, M	4.5 cm, mixed	Partial resection + OT	54 Gy	24 months	–	24 months	10×7 mm cystic	–
2[b] 40, M	2.5 cm, mixed	Partial resection	56 Gy	124 months	–	15 months	10×5 mm solid	–
3[b] 44, M	3.0 cm, mixed	Partial resection	60 Gy	36 months	–	13 months	5×5 mm solid	–
4 3, F	3.6 cm, cystic	Partial resection + OT	50 Gy	76 months	–	43 months	10×10 mm solid	54 months
5 10, F	3.0 cm, solid	Partial resection	54 Gy	38 months	2 months	6 months	–	–
6 34, F	3.0 cm, solid	Partial resection	52.2 Gy	86 months	1.5 months	68 months	4×4 mm cystic	–
7 52, M	4.5 cm, cystic	Partial resection + OT	50 Gy	73 months	1 month[a]	43 months	3×6 mm cystic	–
8 54, F	3.8 cm, cystic	Cyst evacuation + OT	65 months	–	21 months	5×3 mm solid	–	

[a]Cyst evacuation was performed for cystic enlargement
[b]Cases examined during RT

doses ranged from 48 Gy to 60 Gy (median: 54 Gy) with a daily fraction size of 1.8–2.0 Gy.

MR imaging and/or CT were carried out on all patients before and after therapy. Three of the eight patients were also examined during postoperative RT with MR imaging and/or CT. These three patients had solid and cystic tumors and underwent partial resection. For these three patients, images were taken as follows: at 6–20 days (median: 14 days) prior to the initiation of postoperative RT, at irradiation of 20–26 Gy (median: 24 Gy), at irradiation of 36–40 Gy (median: 38 Gy), and at 2–10 days (median: 6 days) after completion of postoperative RT.

Results

Tumors were controlled in seven of eight patients after postoperative RT. The 5-year tumor control rate and survival rate were 80% and 100%, respectively.

The periods of tumor shrinkage ranged from 6 months to 68 months (mean: 29.1 months) after completion of postoperative RT (Table 1). Temporary enlargement of the solid component or cystic component of the tumor was often observed during or after RT.

Temporary enlargement of the solid component was observed in all three patients who were examined during RT. In these patients, the solid component was enlarged remarkably in the first half of postoperative RT and began to shrink after the administration of 40 Gy or more (Fig. 1). The enlargement during RT was observed only in the solid component, and notable cystic enlargement did not occur. Continuous enlargement of the solid component did not occur during or immediately after RT.

Cystic enlargement was observed in three of eight patients after completion of postoperative RT. The times of appearance of cystic enlargement were 1, 2, and 15 months after completion of postoperative RT. One of these patients underwent evacuation of the contents of the cyst immediately after enlargement began, and enlargement did not recur. In the other two patients, the size of the cystic component had decreased by the next follow-up, without any treatment. Continuous cystic enlargement did not occur around the time of postoperative RT, and none of the patients experienced deterioration, such as hydrocephalus or visual disturbance, during the follow-up period.

After completion of tumor shrinkage, small nodules often remain. In six of seven patients who did not experience tumor regrowth, remnant nodules less than 10 mm in diameter were seen at the last follow-up (24–124 months, median: 69 months) (Fig. 2). Three of these nodules were solid, and the other three were cystic. These remnant nodules were stable.

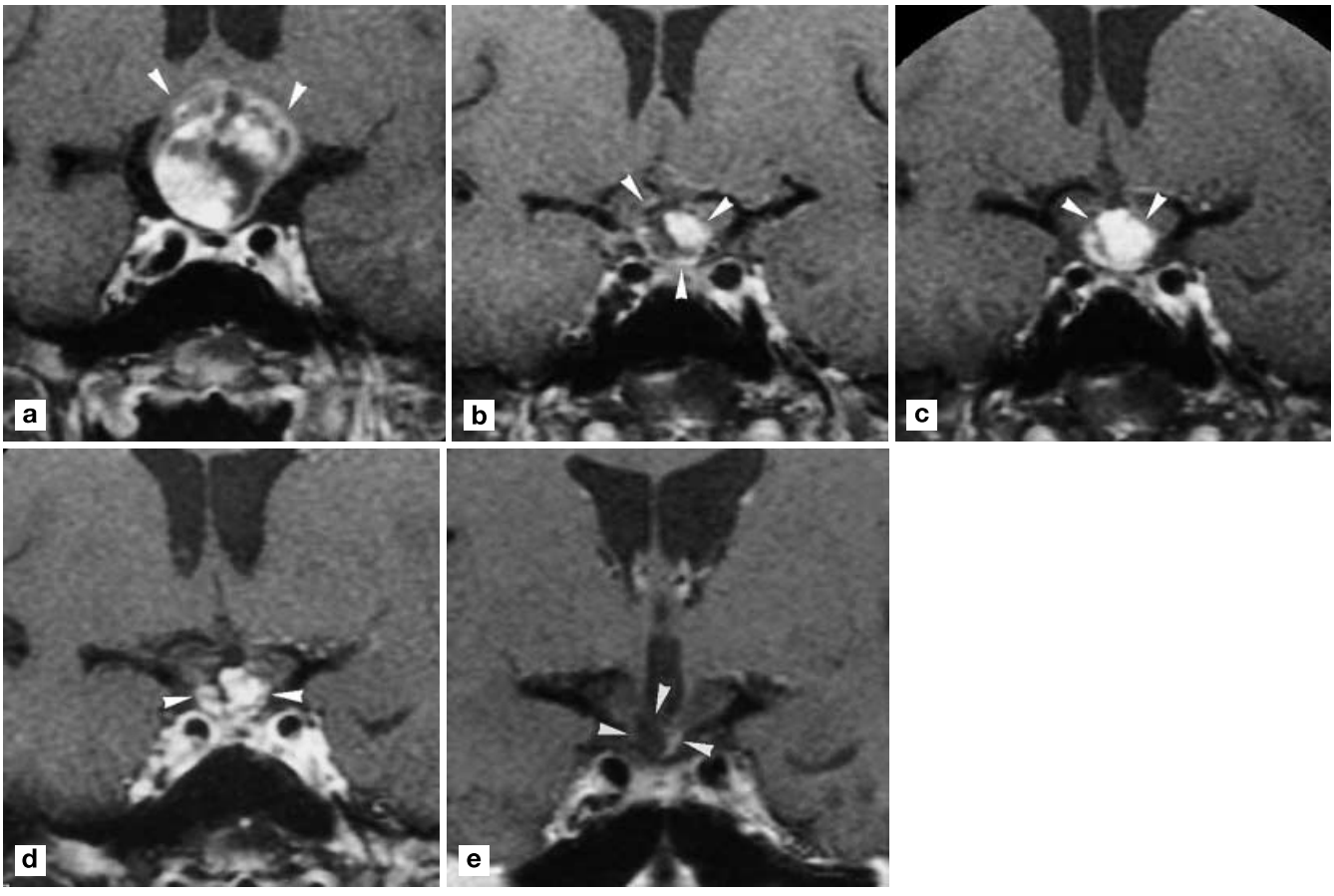

Fig. 1a–e. The course of craniopharyngioma treated with postoperative radiation therapy (RT) on MR imaging in a 44-year-old man. **a** Contrast-enhanced T1-weighted image obtained preoperatively reveals solid and cystic tumor in suprasellar cistern (*arrowheads*). **b** Contrast-enhanced T1-weighted image obtained 16 days after partial resection reveals remnant solid and cystic tumor (*arrowheads*). **c** Contrast-enhanced T1-weighted image obtained at 24 Gy revealed marked enlargement of solid component without remarkable change of total tumor size (*arrowheads*). **d** Contrast-enhanced T1-weighted image obtained at the completion of RT reveals further shrinkage of solid component (*arrowheads*). **e** Contrast-enhanced T1-weighted image obtained 8 months after RT reveals further shrinkage of remnant component of tumor (*arrowheads*)

Local recurrence occurred in one patient, a 3-year-old girl with a cystic-type tumor treated with partial resection and postoperative RT of 50 Gy. Her tumor continued to shrink for 43 months and changed from a cystic tumor to a solid tumor after completion of postoperative RT. At that time, tumor size was 10 mm in diameter. Tumor enlargement was revealed by the next follow-up MR imaging, performed 54 months after postoperative RT. Further enlargement was observed on the MR imaging performed 5 months later. Because of continuous tumor enlargement, total resection of the tumor was performed 6 months after tumor regrowth was pointed out.

Discussion

Recently, the usefulness of postoperative RT with precise planning based on MR imaging or CT has been recognized [6, 7, 8]. Though the importance of postoperative RT has been recognized, the course of this tumor during and after RT has not been reported in detail. The problem with posttreatment follow-up of craniopharyngioma is that the tumor changes continue for a long time after RT, and tumor recurrence can occur after a long interval. Knowledge of the common course of this tumor during and after RT is helpful for diagnosing uncontrolled tumors.

In our series, all tumors shrank after RT. The periods of tumor shrinkage ranged from 6 to 68 months (mean: 29.1 months). Craniopharyngioma was sensitive to RT; however, the periods of tumor shrinkage were often long and varied. Furthermore, temporary tumor enlargement was often observed during or after RT.

In all three patients observed during postoperative RT with MR imaging or CT, the solid component of the tumor grew in the first half of postoperative RT and began to shrink after being irradiated with 40 Gy or more. Since the tumors finally shrank after RT, this phenomenon was not due to radioresistance. Though the

Fig. 2. Remnant component after completion of shrinkage. Contrast-enhanced T1-weighted MR image obtained 8 years after RT reveals remnant component of tumor. In this case, the tumor continued to shrink for 15 months and showed no change for 7 years subsequently (*arrowheads*)

temporary enlargement of the solid component during RT occurred frequently in our series, this phenomenon has not been reported in detail. This enlargement of the solid component may be caused by tumor edema associated with an increase in permeability of tumor vessels induced by irradiation. The temporary enlargement of the solid component during RT should be differentiated from tumor progression. RT can be continued with close follow-up even if the enlargement of the solid component is observed during RT, as long as acute deterioration does not occur.

Temporary cystic enlargement was observed after postoperative RT in a relatively high proportion of patients within 2 years of postoperative RT. In spite of conservative management, the enlarged cysts had decreased in size by the next follow-up imaging and did not enlarge again. Rajan et al. [9] reported that cystic enlargement occurs before RT, during RT, and within 2 months of completion of RT in a significant proportion of patients with craniopharyngioma. They said that cystic enlargement is the main cause of acute deterioration around the time of RT and it is difficult to predict deterioration caused by cystic enlargement. In our series, cysts that were enlarged after RT decreased in size with conservative treatment or no treatment, indicating that immediate surgical intervention is not always necessary as long as the enlarged cyst is small and does not induce deterioration. Cystic enlargement after RT did not always mean tumor recurrence; however, it should be noted, because it induces deterioration sometimes. Rajan et al. recommended close follow-up for at least 2 months because most cystic enlargement occurs early after conservative surgery. Careful observation with CT or MR imaging is necessary when cystic enlargement occurs after RT. Temporary enlargement of the solid component during RT and cystic enlargement after RT often occurred in patients treated with incomplete resection or conservative surgical intervention followed by RT, and these changes did not always indicate tumor recurrence. When tumor enlargement occurs, careful follow-up should be done.

After tumor shrinkage had stopped, small solid or cystic nodules 10 mm or less in diameter remained in most cases. These remnant nodules were stable for a long time. It is not necessarily easy to differentiate uncontrolled tumors from controlled tumors with MR imaging or CT. It has been reported that tumor recurrence has occurred from 5 months to 13.7 years after postoperative RT [6, 10, 11], proving that tumor recurrence can occur after long intervals. We could not determine the necessary and sufficient follow-up periods for craniopharyngioma after RT. Habrand et al. advocated that long-term follow-up beyond 5 years is warranted to assess tumor control after RT [12]. We also believe that such long-term follow-up is necessary to differentiate uncontrolled tumors from controlled tumors.

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