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Fronto-basal interhemispheric approach for craniopharyngiomas extending outside the suprasellar cistern

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Abstract *Objective:* The aim of the present study was to establish the usefulness of the fronto-basal approach with a relatively small craniotomy window for the removal of tumors protruding from the sellar–suprasellar region to the third and basal cistern. *Method:* Forty-two patients who were surgically treated for craniopharyngiomas extending outside the sellar–suprasellar region were evaluated. All the patients were operated on by the fronto-basal interhemispheric approach, and the average follow-up period was 5 years. *Results:* Gross total resection of the lesion was achieved in 30 cases. Eight patients underwent subtotal resection and four patients underwent partial removal due to recurrence after previous surgeries with or without radiotherapy. In the immediate postoperative period, major complications, including impairment of the cranial nerves, were observed in two cases. One patient exhibited transient memory disturbance due to infarction of the perforator; after 3 months, this symptom was ameliorated. Three of the patients died during follow-up; however, 6 of the 30 undergoing gross total removal and 10 of the 12 patients undergoing subtotal or partial removal suffered regrowth. Ultimately, a total of 12 patients underwent re-operation with the same approach or combined with the orbito-zygomatic approach. *Conclusion:* In our experience, the fronto-basal interhemispheric approach, even through a small craniotomy window, is a valid choice for the removal of craniopharyngiomas extending outside the sellar–suprasellar region. Using this approach, tumors can be removed without significant sequelae related to surgical technique due to easy preservation of the pituitary stalk, hypothalamic structures, and perforators. This approach offers a safe and minimally invasive means of treating craniopharyngiomas.

Keywords Craniopharyngioma · Surgery · Fronto-basal interhemispheric approach

Introduction

Despite the benign histological appearance of craniopharyngiomas, many patients demonstrate a progressively deteriorating course, regardless of therapy, and die of their disease. Their treatment has thus presented a challenge to the neurosurgeon. Although surgical mortality has been reduced with the advent of microsurgical techniques and improved endocrinological management in the perioperative period, there is continued appreciation of the morbidity associated with attempted radical excision, particularly with regard to hypothalamic function [6, 7, 12, 28]. Thus, before deciding on a management plan, the neurosurgeon must consider the risks of hypothalamic or major vessel

damage caused by aggressive surgery; cognitive deficit in the young brain or second tumors and cerebral infarction induced by irradiation; and increased morbidity as a result of recurrent disease [8, 20, 21, 27].

Craniopharyngiomas extending into the third ventricle and basal or prepontine cistern present peculiar surgical and clinical problems because of their deep localization as well as their relationship with hypothalamic structures and perforators. Many surgical approaches have been

Table 1 Summary of cases

Case	Sex	Signs and symptoms	Previous treatments	Age at surgery	Removal	Posttreatment	Age at present	Endocrine status at follow-up
1	M	ICP		2	GT	VPS, removal	7	Normal
2	M	ICP		2	GT	SPS	9	Normal
3	F	ICP		2	Subtotal	SPS, removal	6	Hypopituitary, DI
4	F	Hypopituitary, visus		4	GT	VPS	8	Hypopituitary
5	F	ICP		4	GT	SPS	9	Hypopituitary, DI
6	F	ICP		5	GT	RS, removal	9	Hypopituitary
7	M	ICP		6	GT	SPS	13	Normal
8	M	Visus		7	Subtotal	RS, removal	14	Normal
9	M	Visus	Removal (2), RS	7	Subtotal	RS, removal	12	Hypopituitary, DI
10	F	Visus	Removal (3), RS	9	GT	Removal	12	Hypopituitary, DI
11	F	Hypopituitary	Removal, RS	11	GT		15	Hypopituitary, DI
12	M	ICP, visus		11	Subtotal	RS, removal	15	Hypopituitary
13	F	Hypopituitary, visus	Removal, RAD	12	Partial		16	Hypopituitary, DI
14	M	Hypopituitary		13	GT		18	Hypopituitary
15	M	Hypopituitary, visus	Removal (2)	14	GT		20	Hypopituitary, DI
16	F	Hypopituitary, visus	Removal	15	GT		20	Hypopituitary, DI
17	M	Hypopituitary, visus	Removal, RAD	15	GT		21	Hypopituitary
18	M	ICP, hypopituitary	Removal (3), RAD	16	Partial		23	Hypopituitary, DI
19	M	Hypopituitary, dementia		16	GT		18	Hypopituitary, DI
20	M	Hypopituitary		16	GT	RS	22	Hypopituitary
21	F	Hypopituitary	Removal, RAD	25	GT		31	Hypopituitary
22	M	Visus		30	Partial	Removal	34	Hypopituitary, DI
23	F	Hypopituitary, visus		31	GT		36	Hypopituitary
24	F	Hypopituitary	Removal, RAD, RS	31	GT	Removal	D	Hypopituitary
25	M	Visus		38	GT		40	Normal
26	M	Hypopituitary, visus		43	GT		45	Hypopituitary, DI
27	M	Visus	Removal, RAD, RS	44	GT		48	Hypopituitary, DI
28	F	Headache, visus, memory		46	GT	RS, removal	D	Hypopituitary, DI
29	M	Hypopituitary		47	GT		51	Hypopituitary
30	F	Visus		48	GT		57	Normal
31	M	Hypopituitary, visus		48	GT		50	Hypopituitary, DI
32	M	Hypopituitary, dementia		48	GT		53	Hypopituitary, DI
33	F	Hypopituitary, visus	Removal (3)	48	Subtotal	Removal	51	Hypopituitary, DI
34	F	Hypopituitary, dementia		49	GT		52	Hypopituitary
35	M	Hypopituitary, visus	Removal	50	Subtotal		D	Hypopituitary, DI
36	F	Visus		51	GT	RS	54	Normal
37	M	Hypopituitary, visus	Removal (2), RS	52	Subtotal		56	Hypopituitary, DI
38	F	Hypopituitary, visus		58	GT		63	Hypopituitary
39	F	Dementia		58	Subtotal	Removal	63	Hypopituitary, DI
40	M	Hypopituitary, visus		60	GT		62	Hypopituitary, DI
41	M	Visus		63	GT		64	Hypopituitary, DI
42	M	Visus		66	Partial		67	Normal

ICP elevation of intracranial pressure, *RS* radiosurgery, *RAD* radiation, *visus* visual disturbance, *GT* gross total, *VPS* VP shunt, *SPS* SP shunt

used for the removal of these tumors, including pterional, subtemporal, subfrontal, interhemispheric, trans-lamina terminalis, transcortical, and transcallosal approaches. Since 1995, we have operated on craniopharyngiomas extending into the third ventricle or basal cistern via a fronto-basal interhemispheric approach with a relatively small craniotomy window, planning for radical surgical removal whenever possible. We report our series of 42 cases (including 14 previously operated but recurrence cases) that were surgically treated via this approach.

Clinical materials and methods

Patient population

A total of 42 patients were evaluated in this study (Table 1). The study included 18 females and 24 males whose age at the time of surgery ranged between 2 and 66 years (22 patients were younger than 16 years). Of the 42 patients, 14 had undergone previous surgical exploration and/or radiotherapy in other hospital, often with only partial excision of tumor. Each of these patients experienced symptomatic recurrence or uncontrolled growth of their original tumor. In all 42 cases, whether at the primary surgery or at a later operation after previous exploration, an attempt was made to remove the tumor totally.

Operative methods and surgical approach

Bicoronal skin incision and scalp elevation

Under general anesthesia with orotracheal intubation, the patient was positioned supine. The head was fixed centrally in a three-point pin head rest. The vertex was rotated about 5° toward the floor, placing the head in slight extension. The scalp was incised through the galea, beginning just 3–4 cm anterior to the tragus and staying within the hairline as illustrated (Fig. 1). The galea from the pericranium was elevated using sharp dissection. At the superior temporal line on each side, the connective tissue layer over the temporalis fascia contiguous with the pericranium medially was elevated with the galeal layer. This procedure offered a correct plane to split the anterior temporal fat pad and protected the frontalis branches of the facial nerve. Elevation of the scalp flap was continued forward, preserving the bilateral supraorbital nerve adherent to the galea. This galeal layer was separated from the pericranium until reaching the supraorbital rim. The pericranium was incised at the middle portion of exposure and along the vertical line up to the supraorbital nerve bilaterally. The periosteum was elevated in the midline to the nasofrontal suture, and finally a large pericranial flap was elevated and held anterior.

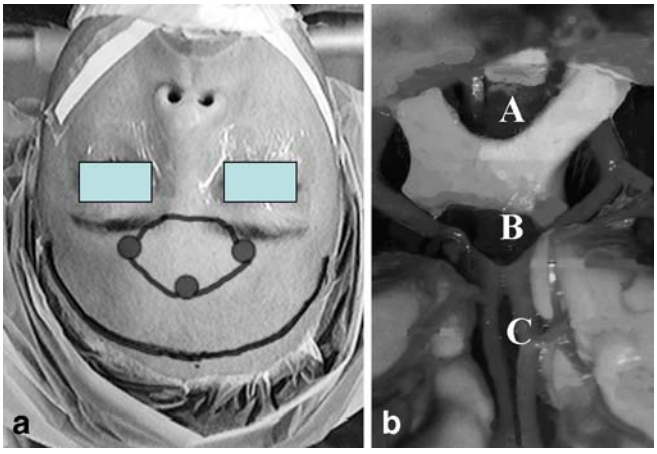

Fig. 1 **a** Schematic drawing of the skin incision, cranial window. **b** Three routes for tumor removal (*A*, *B*, *C*)

Bifrontal craniotomy

Craniotomy was performed under the incised pericranium area. First, a burr hole was placed on each side at the superior orbital margin near the supraorbital nerve. One burr hole was then placed on the midline 4 cm away from the nasofrontal suture. Using the craniotome, a craniotomy was performed as low as possible on the orbital roofs. The frontal sinus was opened in almost all cases, and antiseptics were applied. The mucous membrane within the sinus was not dissected or cauterized in order to further inflammation, but the internal bone lamina of the sinus was removed to decrease the dead space. With a high-speed drill, the crista galli and the residual bone were remove near the nasofrontal suture. Finally, carefully releasing the bone flap of all-dural attachments, the bone flap was cut in one piece as illustrated.

Dural incision

The dura was opened transversely, along the anterior orbital bone edge as far forward as possible in order to minimize damage to the frontal bridging veins (Fig. 2a). The self-retaining retractor blades were repositioned to place some traction across the arachnoid enveloping the frontal lobes. The falx cerebri was also cut as far forward as possible and bleeding of the severed end of the superior and/or inferior sagittal sinus was easily stopped by electrocoagulation.

Elevation of the basal frontal lobes, exposure of the chiasm and lamina terminalis cisterns, and Acom complex exposure

The next step was to enter the basal interhemispheric fissure. At this stage, we usually made special note of how

much of the floor of the tuberculum sellae and optic chiasm we could expose, and the degree of frontal lobe retraction required. The frontal basal area was inspected under the microscope and the increased exposure was noted with relaxed retraction of the frontal lobes. Via a sharp antegrade basal interhemispheric dissection, the chiasm cistern and then the lamina terminalis cistern were extensively exposed (Fig. 2b). After extensive exposure of the lamina terminalis and chiasm cistern, the anterior communicating artery, and bilateral A1 and A2 usually came into view (Fig. 2c). At this stage, since surgical procedures were performed along the border of the rectal gyrus, damage to the medial surface of the cerebral hemispheres was minimal and subsequent removal of the tumors was easy.

Tumor removal

As a final step in tumor exposure, three routes can be exposed (Fig. 1b). Make a survey of the entire exposure, including the anterior and lateral parts of the optic chiasm, the organum vasculosum of the lamina terminalis located between the optic chiasm and the anterior communicating artery, and the deep upper-posterior part of the lamina terminalis. For patients undergone primary surgery, dissection and separation of the capsule of the tumor from the surrounding structures are not difficult. If the space anterior to the optic chiasm is wide, we perform intracapsular decompression first and do not open the lamina terminalis. However, if the space is narrow, we puncture the lamina terminalis on its avascular part with a needle, and a small amount of the fluid is aspirated if the tumor is cystic. Even removal of 1 or 2 ml of fluid produces space for dissection to render later procedures easier. Incising the lamina terminalis allows dissection while directly observing the retro-chiasmal portion of the tumor from the hypothalamus. If the tumor contains solid portions and is covered by the stretched floor of the third ventricle, intracapsular decompression is performed first. Coagulation by bipolar forceps is avoided as much as possible to prevent damage to the hypothalamus. Pressing with a cottonoid simply controls small amounts of bleeding. The continuity between the median eminence and pituitary stalk should be preserved on either side to maintain pituitary function. We find the stalk when dissecting the wall of the tumor from the floor of the third ventricle. The remaining part of the tumor is usually not as firmly adherent to the surrounding structure as to the floor, and it can be removed either through the lamina terminalis or the prechiasmatic space. Vigorous retraction of the tumor capsule adherent to the third ventricle or major vascular structures usually results in a dense bitemporal hemianopsia and hypothalamic dysfunction secondary to vascular damage. In some cases, the anterior communicating artery is close to the optic chiasm. We perform tumor removal via bilateral A2 space (Fig. 1) without sacrificing the communicating artery and its perforators to the corpus callosum and hypothalamus [17], particularly in pediatric patients.

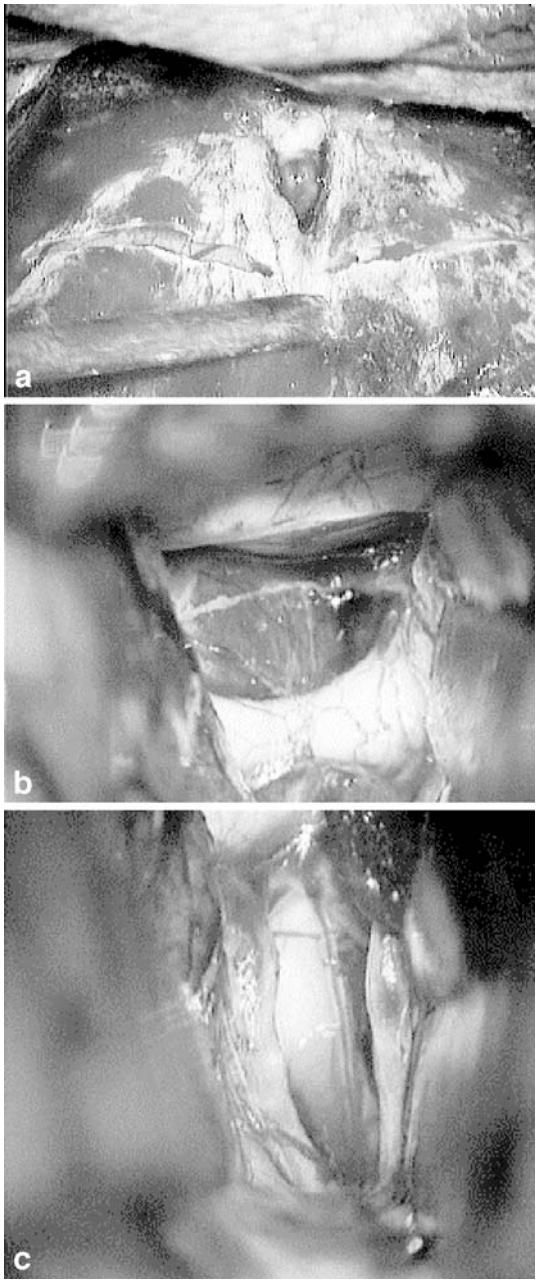

Fig. 2 **a** The dura was opened transversely, along the anterior orbital bone edge. **b**, **c** The chiasm cistern and lamina terminalis cistern were exposed. The anterior communicating artery, bilateral A1 and A2 are seen

Delivering and dissecting a tumor capsule from the third ventricle may be difficult; however, the capsule will come down if adequately debulked with gentle traction and under direct microscopic vision. In our experience, tumor invasion is separated from the nuclear masses by a surrounding barrier of glial cells, which facilitates dissec-

tion. With the roof of the capsule decompressed, vascular structures including the perforators will be visible. Again, the investing layer of arachnoid allows dissection of the capsule from the internal carotid and posterior communicating arteries, and thalamoperforating branches. At this stage, the tumor has been removed from all structures except the posterior aspect of the optic chiasm with which it may be firmly adherent. It is possible to free the tumor by very sharp dissection from the posterior aspect of the optic chiasm, if the optic nerves are not short. This operative technique has allowed radical removal of the tumor in 22 cases. Densely calcified tumor may be adherent to the medial aspect of the major artery. When we cannot create a plane between a calcified mass and the arterial wall, we abandon the radical procedure and leave the calcified portion, particularly for those patients who have recurrence after previous surgeries with radiotherapy.

Illustrative cases

Case 2

This 2-year-old boy exhibited intermittent headaches and vomiting for 2 weeks. Magnetic resonance (MR) studies obtained in April 1996 revealed a hydrocephalus and a 4-cm-wide cystic mass in the sellar–suprasellar and the entire third ventricular region. On admission, signs of choked discs were observed. On April 23, 1996, total removal of the tumor through a fronto-basal interhemispheric approach was performed. The postoperative course was uneventful. Two weeks after the operation, a subduroperitoneal shunt was placed due to subdural effusion. Transient diabetes insipidus was controlled by DDAVP in the acute stage. Following a thorough hormone study, cortisone was administered from the subacute stage after the operation. He was discharged from our hospital on July 17, 1996, without neurologic or psychological problems. The steroid agent was withdrawn 3 months after the operation in the pediatric department of Tohoku University (Fig. 3).

Case 14

This 7-year-old boy developed intermittent severe global headaches from July 1997. MR studies revealed an enhancing mass involving the sellar–suprasellar and the prepontine region (Fig. 4a). On admission, an upper bitemporal hemianopsia was observed. On 19 August 1997, nearly total removal of the tumor through a fronto-basal interhemispheric approach was performed, except for

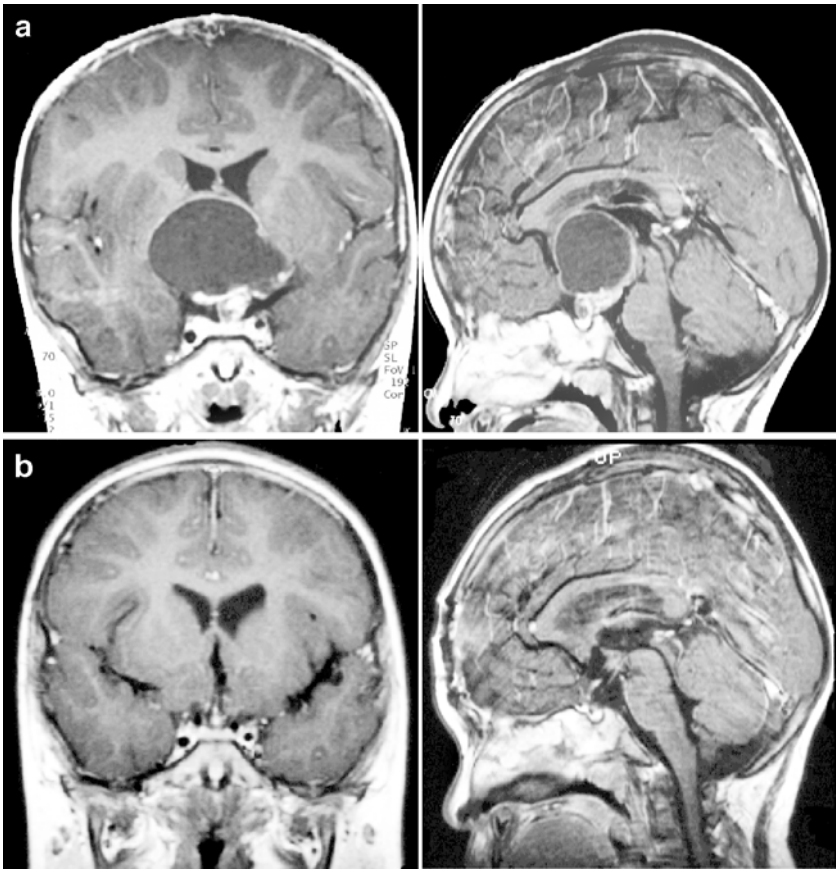

Fig. 3 MRI T1 revealed a cystic tumor in the sellar–suprasellar and the entire third ventricular region. **a** Pre-, **b** post-operative

a small part adherent to the pituitary stalk (Figs. 4b and 5a). The postoperative course was uneventful. The bifrontal subdural effusion spontaneously remitted, and transient diabetes inspidus was also controlled by DDAVP in the acute stage. Following a thorough hormone study, growth hormone was administered from the subacute stage after the operation. He was discharged from our hospital on September 17, 1997, without neurologic or psychological problems. His vision and visual field improved gradually, and steroid agent was withdrawn 3 months after operation in our outpatient clinic. However, 1 year later, a cystic mass was newly observed in the region of the left pituitary stalk. Although gamma knife surgery (peripheral dose 9 Gy) was performed, the mass gradually enlarged by followed MR images. Because signs of upper bitemporal hemianopsia recurred, on November 2, 2000, total removal of the newly developed tumor was undertaken through the same approach as in the first operation (Fig. 5b). MR studies revealed a cystic mass involving the suprasellar region, which slightly compressed the optic chiasm (Fig. 4d). No tumor recurrence was observed on the most recent magnetic resonance imaging (MRI) in June 2001 (Fig. 4e). The structure and function of the pituitary stalk were preserved both on MRI and hormone study. His visual defect recovered soon after the second operation. He is being followed in the pediatric department for growth hormone therapy.

Case 19

This 14-year-old boy who presented with easy fatigue and progressive dementia. Computed tomography scanning and MRI results revealed a sellar–suprasellar-prepontine cystic mass with calcification. The patient underwent total resection of the tumor; however, at the final stage of the microscopic operation, hemorrhage in the deepest portion of the calcified tumor unintentionally occurred. The bleeding point could be easily controlled by the coagulation procedure, but the patient's condition was complicated by

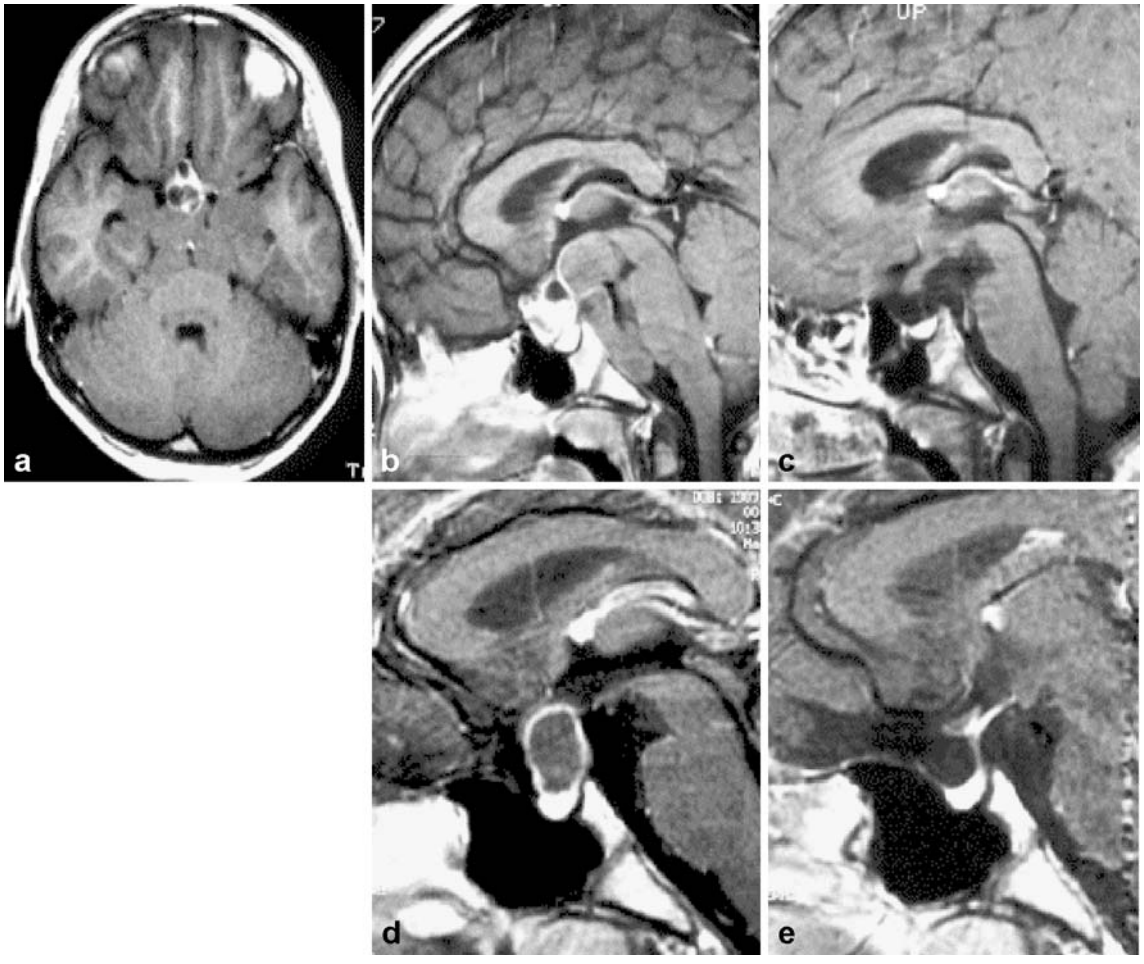

Fig. 4 MRI revealed an enhancing mass involving the sellar–suprasellar and the prepontine region (**a**, **b**); nearly total removal of the tumor through a fronto-basal interhemispheric approach was performed (**c**). Cystic mass involving the suprasellar region (**d**). Total removal of the tumor was performed (**e**)

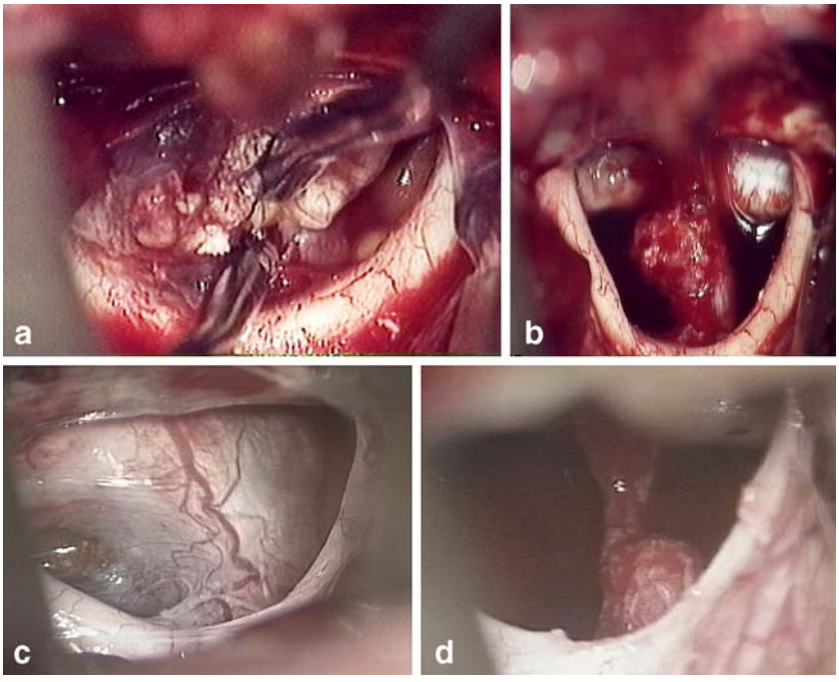

Fig. 5 **a**, **b** Removal of the tumor was performed, except for a small part adherent to the pituitary stalk. **c**, **d** The tumor at second surgery and the pituitary stalk after total removal

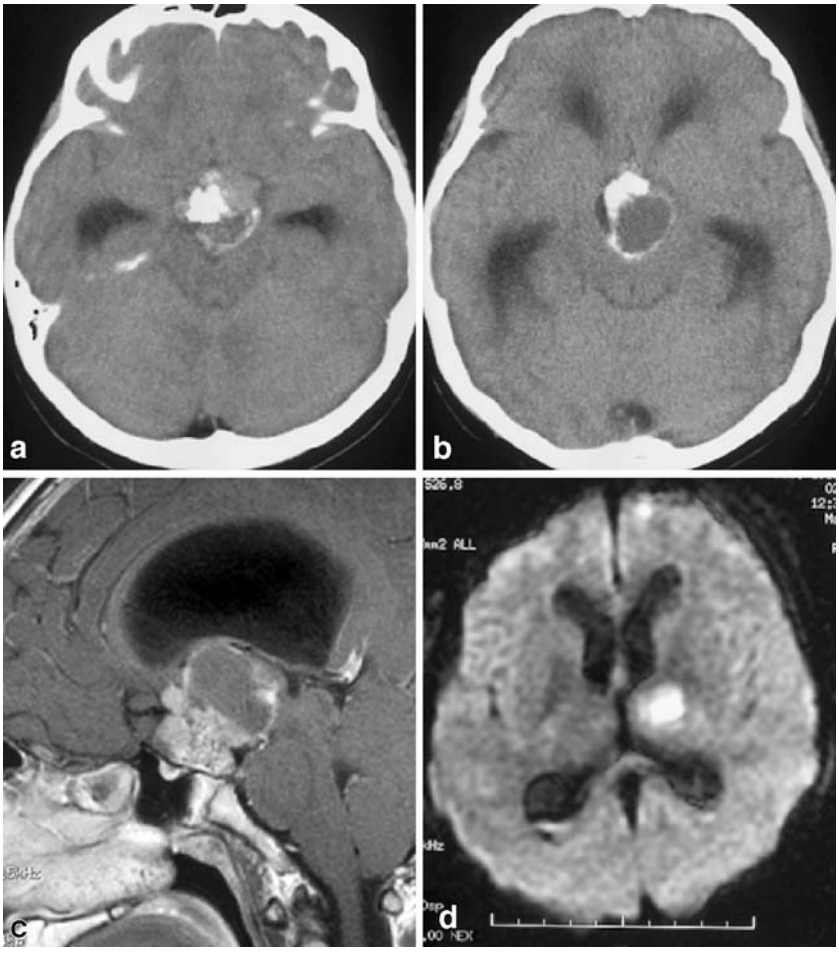

Fig. 6 CT (**a**, **b**) and MRI (**c**) revealed the calcified and cystic components extending over the sella and in the pre-pontine area. **d** MRI revealed thalamic infarction due to damaging the perforator from the posterior cerebral artery (PCA)

a small area of thalamic infarction. As a consequence, it took a long time to recover from the symptoms and signs of the complication (Fig. 6).

Results

Gross total removal of the lesion was achieved in 30 cases. Eight patients underwent subtotal resection and four patients underwent partial removal due to hard calcification or recurrence after previous surgeries with or without conventional radiotherapy. In the immediate postoperative period, two major complications were observed. Three patients died during long-term follow-up; however, 6 of the 30 patients undergoing gross total resection and 10 of the 12 patients undergoing subtotal or partial removal suffered recurrence. Of the 16 patients with recurrence, seven experienced small recurrence of the lesion; after radiosurgery by gamma knife, two of the lesions exhibited unchanged size and five patients underwent re-operation due to enlargement of the tumor in the follow-up period. Ultimately, a total of 12 patients underwent re-operation with gross total removal with the same approach or the orbito-zygomatic approach for patients with very short optic nerves.

Cases 19 and 31 exhibited memory disturbance due to infarction of the perforators or intraventricular hemorrhage at the final stage of a rather hard tumor removal.

Of the 19 pediatric patients, 15 were taking a combination of thyroid, cortisone, and DDAVP. Almost adult patients required a permanent replacement of hormone therapy for hypopituitarism and/or diabetes insipidus. Preexisting mild psychological disturbances remained in the postoperative period, and the immediate surgical results were good.

The patients, who underwent partial or subtotal removal, after direct re-operation or by gamma knife, returned to their normal life, with persistence of the psychological disturbances and hypopituitarism that were present before surgery. Visual functions were preserved or improved for all patients.

Discussion

According to the vertical axis of extension for craniopharyngiomas, Samii and Tatabiba [18] classified these tumors into five types and Yarsagil et al. [28] divided them into six types. It has been reported that intrasellar or intracisternal tumor located in the sub-diaphragm portion can be treated by a transsphenoidal approach. Tumors extending to the lower part of the third ventricle can be treated by the transcallosal or transcortical approach, and small retrochiasmal craniopharyngiomas can be removed by the subtemporal approach. For those tumors extending to the posterior fossa, the trans-petrosal approach can be used. However, these tumors are very often of a mixed type. Craniopharyngiomas protruding from the sellar–suprasellar region to the third or lateral ventricle or septum pellucidum (Samii's classification type III, IV, and V) present a particular problem because of the difficulty of reaching and the risk of producing damage to the optic pathways and the hypothalamus. The classifications of both Samii and Yarsagil indicate that these extending craniopharyngiomas differ from the more common suprasellar infundibular craniopharyngiomas with respect to clinical features, neuroradiological findings, and surgical approaches. Thus, various surgical approaches have been used for their removal.

Suzuki et al. [24, 25] and Shibuya et al. [19] have previously described an interhemispheric approach for the treatment of most craniopharyngiomas. The advantage of this approach is minimal brain retraction. In addition, the arteries and veins along the exposed dorsal and medial surface of the frontal lobe and over the corpus callosum can always be saved. However, surgical techniques using this approach are reported to be complex, and postoperative psychological problems and the olfactory tract damage [23] are another disadvantage of this approach. In most cases, internal decompression, by aspiration of cystic and solid parts of the tumor or piecemeal extirpation of calcified portions, is helpful in gaining space in order to dissect lateral parts of the tumor. However, the irregular relationship between the tumor and the infundibular area, which is thought to be the origin of craniopharyngioma, demands special attention and requires precise inspection and careful dissection. Occasionally, it is very difficult to remove the tumor completely due to strong adhesion between the tumor and the infundibulum. We therefore modified the traditional interhemispheric approach (bilateral subfrontal and interhemispheric approach) and use the basal interhemispheric approach combined with the trans-lamina terminalis approach, that is, the fronto-basal interhemispheric approach [20], to treat craniopharyngiomas protruding from the sellar–suprasellar portion to the ventricles or septum pellucidum. This approach provides a good view of the infundibulo-hypophyseal axis structures and tends not to require strong retraction of the frontal lobes if the lamina terminalis is widely exposed. In addition, we use a relatively small craniotomy window to prevent unnecessary injury to the fornix, the olfactory tracts, the anterior commissure, and the corpus callosum. None have newly developed olfactory dysfunction.

As in our report, the fronto-basal interhemispheric approach is thus useful in the surgical treatment of all craniopharyngiomas. It can be used for tumors that are largely in the ventricles or basal cistern, and it is also useful for large tumor removal when the optic nerves are short; in cases of short optic nerves, if the lamina terminalis is opened, and the tumor can then be pushed from behind, via the third ventricle, under the chasm and between the optic nerves. Moreover, we can approach the lamina terminalis along the inferior surface (fronto-basal) of the frontal lobe

via a small frontal craniotomy above the supraorbital rim, as described above. Unlike the pterional approach combined with trans-lamina terminalis approach, the fronto-basal route provides observation of the third ventricle behind the lamina terminalis even posterior to the aqueduct or to the basilar apex if the floor has been penetrated by the tumor.

The unilateral or bilateral subfrontal approach [18, 28] is widely used for the removal of craniopharyngiomas because it is simple and does not require opening of the interhemispheric fissure. However, this approach has the disadvantage of a relatively narrow operative field compared with the interhemispheric approach. Although Samii has adopted this approach, it tends to result in difficulty in opening the entire lamina terminalis, resulting in strong retraction of the frontal lobes. The pterional approach [7, 15, 26] may offer an accustomed view to the surgeon but have the disadvantage of hiding many vascular structures (such as the internal carotid artery, posterior communicating artery, and anterior choroidal artery) beneath the tumor. Since craniopharyngioma is vascularized by branches of the internal carotid artery, which also supply the pituitary stalk, hemorrhage from the above-mentioned arteries or their branches encountered has been reported in the literature. The pterional combined with the transcallosal approach or trans-lamina terminalis approach is often used for larger tumors, particularly for solid-type craniopharyngiomas. On the other hand, the pure subtemporal approach is used for the treatment of tumors extending into the posterior fossa. Because this approach may easily injure the temporal lobe, the combined trans-petrosal approach [11] or extradural temporopolar approach [5] is used. However, even with the combined approaches, the surgical view is narrow and inconvenient. In our experience, the combined orbito-zygomatic approach [9] is relatively safe for removing tumors behind the optic chiasm and tumors extending into the posterior fossa. Pure intraventricular craniopharyngiomas [10, 13] are rare, and the transcallosal approach [1] is indicated for their treatment. However, great attention should be paid to saving the fornix, the anterior commissure, the choroid plexus, the choroidal arteries, and the septal, striothalamic, and internal cerebral veins. In rare cases, the transcortical approach [28] is selected. However, this approach is usually rejected by neurosurgeons for fear of producing porencephalic cysts or postoperative epilepsy. Moreover, although the contralateral aspect of the third ventricle can be demonstrated using this approach, it is difficult to control ipsilateral dissection.

Craniopharyngiomas are highly resilient tumors that may recur from minute fragments left behind. Postoperative neuroimaging using MR techniques is the only way to accurately assess the completeness of tumor resection. In addition to complete tumor excision, radiotherapy given electively after initial surgery has been reported to be an independent factor related to recurrence [16]. However, there is now a wealth of data to show that excellent long-term tumor control may be achieved using adjuvant irradiation. Six of our patients experienced a small recurrence; after radiosurgery by gamma knife [2–4, 22], two lesions exhibited unchanged size and four underwent re-operation due to enlargement of the tumor during the follow-up period. Variable factors including a maximally tolerable dose to the optic nerves after gamma knife irradiation may be involved [14]. Therefore, further study and long-term follow-up of gamma knife-treated craniopharyngiomas of the present report are essential.

Conclusion

This approach offers a minimally invasive means of treating craniopharyngiomas and evaluating the surrounding anatomy, as well as for determining operative strategy for gross total removal of the tumors.

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