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Basal interhemispheric supra- and/or infrachiasmal approaches via superomedial orbitotomy for hypothalamic lesions: preservation of hypothalamo-pituitary functions in combination treatment with radiosurgery

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Abstract Although several approaches to the hypothalamus have been used, none is able to give full views of the hypothalamus. The risk of permanent morbidity for hypothalamo-pituitary functions is still high, especially in patients with craniopharyngioma. Basal interhemispheric supra-chiasmal or infra-chiasmal approaches via superomedial orbitotomy were developed for better visualization of the hypothalamus. Operative techniques and results, including combination treatment with radiosurgery, are reported. Twelve patients with tumors compressing the hypothalamus upward or extending into the III ventricle, or both, were operated on: 3 tumors were removed totally, 6 tumors subtotally and 3 tumors partially. Six patients received radiosurgery for residual tumor. Four patients with hypopituitarism preoperatively required oral corticosteroids and thyroid hormones postoperatively. The basal interhemispheric approach via superomedial orbitotomy is useful for better visualization of the hypothalamus and preservation of hypothalamo-pituitary functions.

Key words Operative approach · Orbitotomy · Hypothalamus · Craniopharyngioma · Pituitary adenoma · Radiosurgery

Introduction

A number of approaches to the hypothalamus have been developed, including the frontal interhemispheric, basal interhemispheric, transcallosal intraventricular, pterional, orbitozygomatic and petrosal approaches [1, 6, 9, 15, 20]. However, the hypothalamus is formed from the anterior, lateral and inferior walls of the III ventricle. The optic chiasm and the infundibulum of the pituitary stalk consist of anterior and inferior walls of the ventricle. No single approach is able to provide a view of the whole hypothalamus. Although the development of microsurgical techniques has decreased the operative mortality of hypothalamic lesions, the risk of permanent morbidity from hypothalamo-pituitary dysfunction remains very high [10, 17], and many patients require life-long endocrine replacement therapy, especially patients with craniopharyngioma. A glial barrier does not seem to protect the hypothalamo-pituitary function in those patients.

Recent skull base surgical techniques have provided good operative visualization of deep-seated lesions. Based on personal experience of orbital advancement for craniosynostosis, we developed the superomedial orbitotomy for the basal interhemispheric approach [13]. Several reports on the basal interhemispheric approach have described good visualization of lesions in the hypothalamus [2, 20]. Good operative exposure of the hypothalamus is essential to preserve hypothalamo-pituitary function.

In this report, we describe the operative technique of superomedial orbitotomy, an approach that provides improved visualization of the hypothalamus. Operative findings and results are also reported.

Patients and methods

Patients

Seventeen patients underwent removal of a midline tumor via superomedial orbitotomy. Twelve of them had tumors compressing the hypothalamus upward and/or extending into the III ventricle (Table 1). These patients ranged in age from 2 to 73 years (mean 32.3 years). There were 5 patients with a craniopharyngioma, 5 with a pituitary adenoma, 1 with a meningioma and 1 with a mesenchymal tumor. Four patients had a recurrent suprasellar tumor 2–4 years after transsphenoidal surgery (3 pituitary adenomas and 1 mesenchymal tumor). None of the 4 tumors was amenable to total resection by the transsphenoidal approach because of their hard consistency. Pre- and postoperative magnetic resonance (MR) images were examined, and visualization of the hypothalamus and preservation of the pituitary stalk were evaluated. Surgical complications such as rhinorrhea, infection and olfactory dysfunction were also evaluated. Postoperative treatment for residual tumors based on our treatment guidelines, and postoperative medication for hypopituitarism are described.

Operative technique

General anesthesia is induced, and the patient left supine with the head slightly flexed. A bicoronal skin incision is made, preserving the frontal branches of the superficial temporal artery and the frontal branches of the facial nerve. The skin flap is retracted up to the supraorbital region, preserving the pericranium and supraorbital nerves. Then, the pericranium is dissected carefully to the orbital margin, and the periorbita is peeled from the upper margin of the orbita and orbital roof. The nasofrontal suture is then exposed. A bifrontal craniotomy is made using five burr holes (Fig. 1A). The dura is dissected from the orbital roof intracranially. While the dura and periorbita are protected with spatulas, the superior orbital margin and orbital roof are cut perpendicularly, and the nasofrontal sutures are cut horizontally with a bone saw. A superomedial orbital flap is removed with a chisel (Fig. 1A,B). The crista frontalis and the base of the skull in the midline are rongeured to the crista Galli (Fig. 1B). The mucosa in the frontal sinus is removed completely from the bone flap, and the exit of the sinus is temporarily packed with cotton soaked in iodine solution. After changing from craniotomy instruments to microsurgical instruments, the operator moves from the top to the right side of patient. The dura is opened vertically on the right side from the base of the skull, and the falx is cut at the base. The crista Galli is removed intradurally. After interhemispheric dissection, the basal cistern is opened. The olfactory bulb, usually exposed on the right side, is protected by oxycel cotton soaked with fibrin glue. Supra- and/or infrachiasmal approaches are selected according to the site and size of the tumors. After removal of the tumor, the dura is closed tightly. The cotton packing is removed from the frontal sinus, and the sinus is repacked with fat obtained from the lower abdomen and covered with fibrin glue. The orbital flap is returned and fixed with a Teflon suture. The orbital flap and orbital roof are covered with the pericranium and fibrin glue. After tenting sutures have been placed in the dura, the epidural spaces are also packed with fat. The frontal bone flap is fixed with Teflon sutures, and the supraorbital pericranium is approximated tightly to achieve correct positioning of the periorbita and canthal ligaments. The bicoronal incision is closed in layers and drained bilaterally with closed suction drains.

Illustrative cases

Case 1

A 36-year-old woman had undergone transsphenoidal partial removal of a hard pituitary adenoma 4 years previously. The tumor regrew, mainly in the suprasellar region, mildly compressing the hypothalamus and causing a progressive decrease in her visual acuity (Fig. 2A,B). The tumor was removed by the basal interhemispheric infrachiasmal approach via superomedial orbitotomy. The optic chiasma and tracts, the floor of the III ventricle and the pituitary stalk were all visualized and preserved during the operation. The postoperative course was uneventful, and the patient's hypothalamo-pituitary function was preserved (Fig. 2C,D).

Case 2

A 9-year-old girl presented with headaches and bitemporal hemianopia caused by a large multicystic craniopharyngioma. The tumor was compressing the hypothalamus to a moderate degree (Fig. 3A,B). The patient underwent subtotal resection of the tumor by the basal interhemispheric infrachiasmal approach, the hypothalamus and pituitary stalk being preserved. She had an uneventful postoperative course. A residual tumor in the hypothalamus was treated by gamma knife with a peripheral isodose of 30%, 10 Gy, 2 months after microsurgery. The patient is doing well with normal menstruation 2 years after surgery. (Fig. 3C,D).

Case 3

A 2-year-old boy presented with diencephalic syndrome secondary to a huge multicystic craniopharyngioma. There was extensive in-

Table 1 Demographics and clinical characteristics of 12 patients with a hypothalamic lesion undergoing resection (*RS* radiosurgery by a gamma unit, *ERT* endocrine replacement therapy)

Case no.	Age (years)	Sex	Histological diagnosis	Extent of resection	Postoperative treatment	
1	7	F	Craniopharyngioma	Partial	RS	ERT
2	9	F	Craniopharyngioma	Subtotal	RS	
3	47	F	Pituitary adenoma	Partial		
4	2	M	Craniopharyngioma	Subtotal	RS	ERT
5	25	F	Mesenchymal tumor	Partial	RS	ERT
6	25	M	Pituitary adenoma	Subtotal	RS	
7	73	M	Craniopharyngioma	Total		
8	60	M	Pituitary adenoma	Subtotal	RS	ERT
9	45	F	Meningioma	Total		
10	40	F	Craniopharyngioma	Total		
11	36	F	Pituitary adenoma	Subtotal		
12	19	M	Pituitary adenoma	Subtotal		

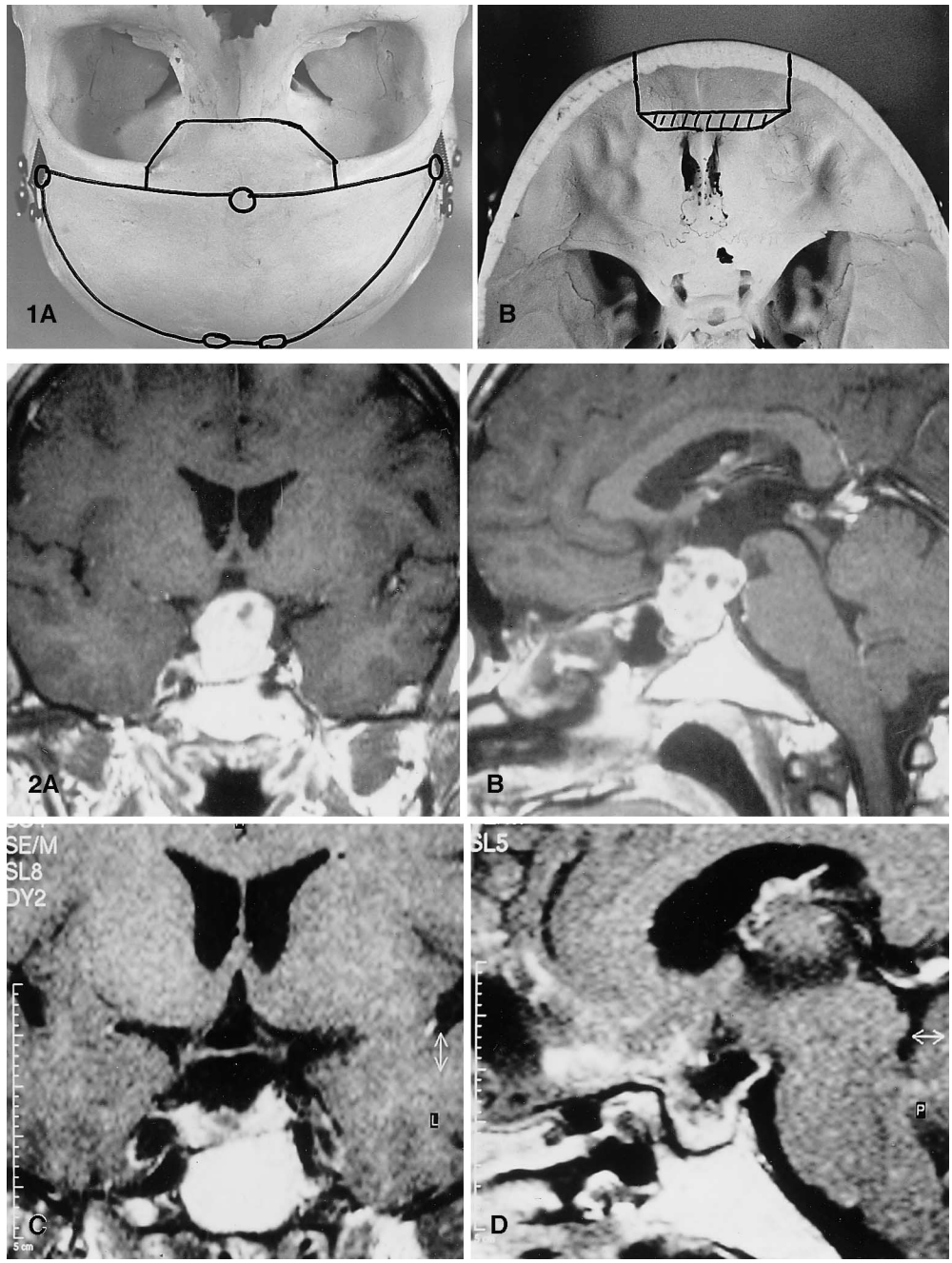

Fig. 1 Representations of **A** frontal craniotomy and **B** superomedial orbitotomy for hypothalamic lesions

Fig. 2A–D A 36-year-old patient with recurrent pituitary adenoma 2 years after transsphenoidal surgery. **A, B** Gadolinium (Gd)-enhanced magnetic resonance images demonstrate a suprasellar mass. The optic chiasm and pituitary stalk are not identified. **C, D** The optic chiasm and pituitary stalk are visualized on postoperative MR imaging

volvement of the hypothalamus (Fig. 4A,B). The tumor was removed subtotally by combined basal interhemispheric suprachiasmal (translamina terminalis) and infrachiasmal approaches. The porus of the aqueduct was exposed after removal of the intraventricular tumor by the suprachiasmal approach (Fig. 4C,D). Five months later, regrowth of the tumor was detected during radiosurgery (Fig. 4E). The patient underwent a second operation, and the tumor was removed totally by the anterior temporal approach (Fig. 4F). No additional deficits were observed postoperatively, although the boy required endocrine replacement therapy for hypopituitarism.

Results

Preoperative MR imaging

The degree of hypothalamic involvement was divided into three categories; mild, moderate, and severe, based on the relationship between the height of the tumor and the level of the aqueduct and foramen of Monro. In the severe group, all three tumors were large, extended beyond the level of

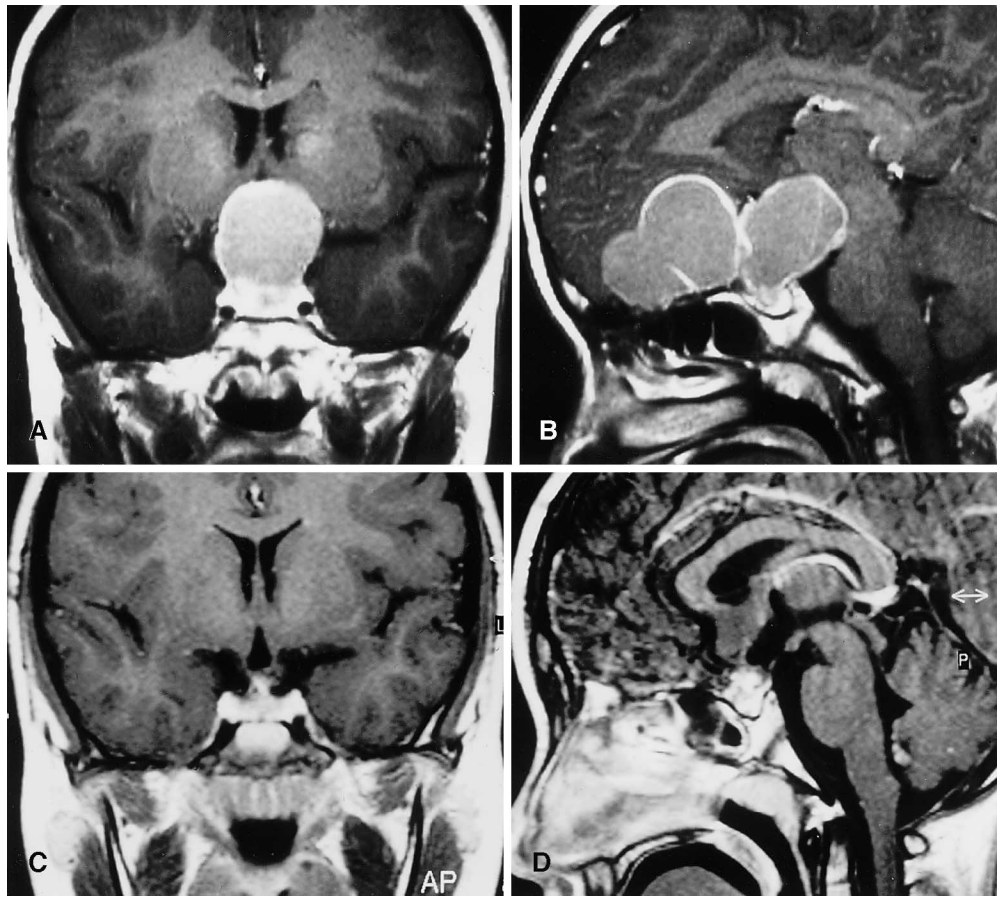

Fig. 3 **A, B** Gd-enhanced magnetic resonance (MR) images of a 9-year-old girl demonstrate a huge multicystic tumor compressing the hypothalamus. The tumor was removed subtotally by the basal interhemispheric infrachiasmal approach. **C, D** Gd-enhanced MR images 2 years after radiosurgery, showing no regrowth of the residual tumor in the suprasellar region

the foramen of Monro, and occupied the entire III ventricle. All these tumors were craniopharyngiomas. In the moderate group, tumors extended up to the level of the foramen of Monro. These included 2 craniopharyngiomas, 1 pituitary adenoma, and one mesenchymal tumor arising from the sella. The other 5 tumors extended up to the level of the aqueduct: 4 of these tumors were pituitary adenomas, and 1 was a meningioma. In 10 patients, the pituitary stalk could not be identified on MR images with three-dimensional sections. Part of the stalk was seen in 1 patient and part of the optic chiasm was visualized on the coronal MR image in 6 patients.

Operative findings

After the superomedial orbitotomy, the frontal sinus was opened in the 9 adults, but not in the 3 children. The sinus was very large and extended to the orbital roof in 1 patient. The supra- and infrachiasmal approaches were combined in 3 patients with severe or moderate hypothalamic involvement. The other 9 tumors, including 1 with extensive hypothalamic involvement verified by MRI, were removed by the infrachiasmal approach. Of the 12 tumors, 3 (2 craniopharyngiomas and 1 meningioma) were removed totally, 6 tumors were removed subtotally and 3, partially. Subtotal removal was due to tumor invasion of the hypothalamus in 2 cases of craniopharyngioma and to a small residual tumor in the sella and cavernous sinus in 4 cases of pituitary adenoma. Partial removal was intentional in the case of 1 craniopharyngioma with a cyst in the III ventricle and of 1 large pituitary adenoma with a hematoma (as a trial in an earlier surgical series). The 1 mesenchymal tumor was removed partially (70%) because it was tightly adherent to the optic chiasm and hypothalamus. The pituitary stalk was not exposed in these 3 patients with partial tumor resection. An internal view of the lateral wall and floor of the III ventricle, including the porus of the aqueduct, was possible by the suprachiasmal approach. The pituitary stalk and floor of the III ventricle were exposed and preserved in 8 patients by the infrachiasmal approach. The stalk was not preserved in only the 1 patient who had the huge craniopharyngioma (case 3).

Tumor invasion of the hypothalamus was found in 3 patients with a craniopharyngioma, and tumor adhesion to the floor of the III ventricle was present in 2 patients. No tumor adhesion to the floor of the ventricle was observed in any patients with a pituitary adenoma or meningioma.

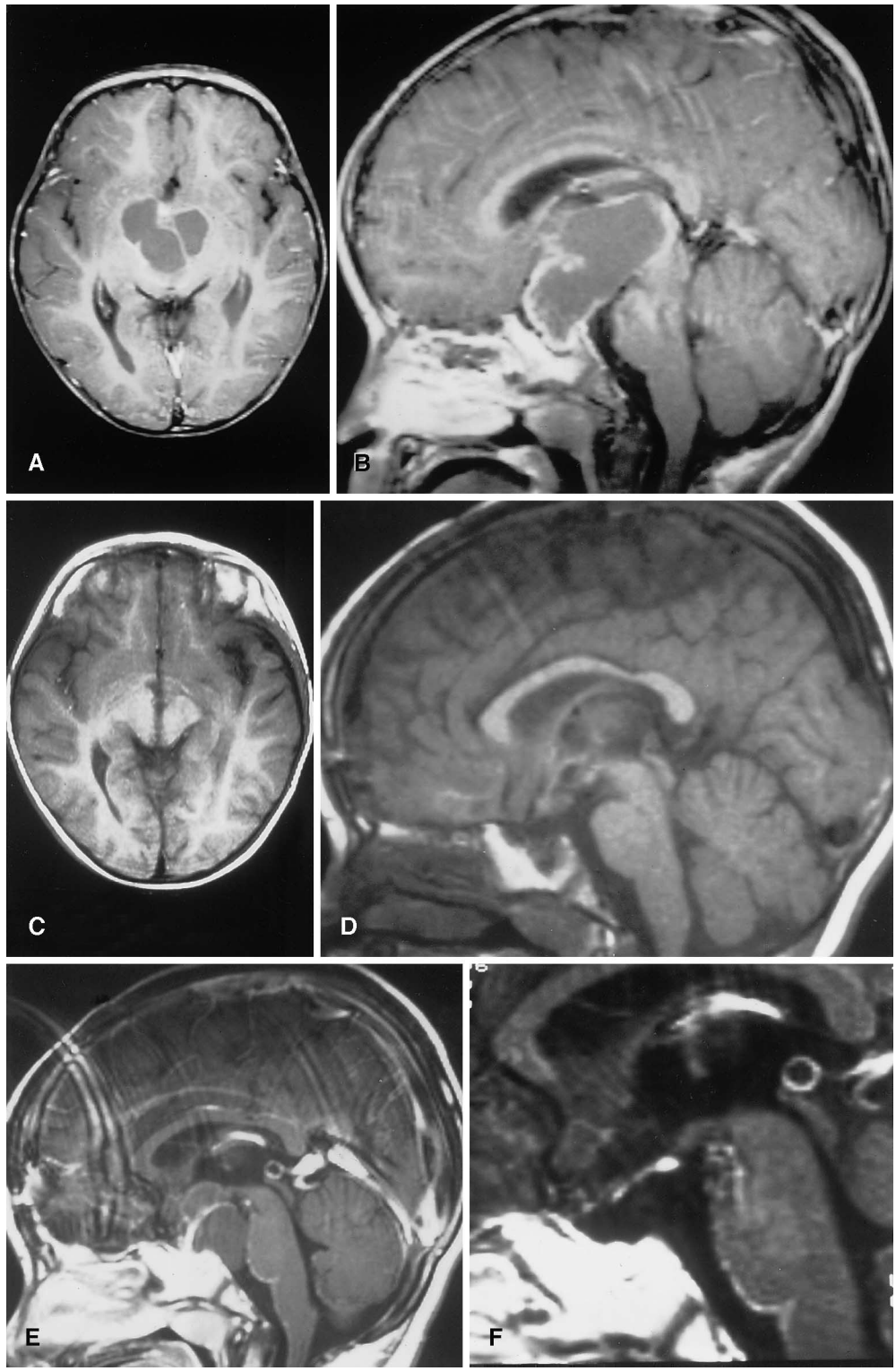

Fig. 4 **A, B** Gd-enhanced MR images of a 2-year-old boy demonstrate a huge muticystic tumor occupying the sella turcica, basal cistern and III ventricle. The tumor was removed subtotally by basal interhemispheric supra- and infrachiasmal approach. **C, D** Postoperative MR image shows no lesion. **E** Regrowth of the cystic tumor in the suprasellar and prepontine cistern 5 months after surgery. **F** MR image after second surgery by anterior temporal approach shows no residual tumor

Postoperative MR imaging

Although residual tumors were observed in the 3 patients who underwent partial resection and the 3 patients who underwent subtotal resection, no residual tumors were found (even on gadolinium-enhanced MR images) in the other 5 patients, including the patients whose resection was subtotal. The optic chiasm was visualized on coronal MR images in all patients but 1 who underwent partial removal of a craniopharyngioma. The pituitary stalk was visualized on coronal and sagittal views in 8 patients (3 with craniopharyngioma, 4 with pituitary adenoma, and 1 with meningioma).

Surgical complications

Transient rhinorrhea developed in 2 patients between 1 and 4 weeks after the operation. However, this resolved with bed rest for several days. No patient developed any infection, nor did any patient complain of anosmia. However, unilateral anosmia was detected on examination in 1 patient. No ophthalmic complications occurred.

Hypothalamo-pituitary function

Transient diabetus insipidus (DI) developed in 6 patients but resolved within 3 weeks. Persistent DI was identified preoperatively in 1 patient and persisted postoperatively. Hyponatremia and a prolonged disturbance in consciousness developed in 1 patient, which lasted for 3 weeks. No patient developed any other sign of hypothalamic dysfunction, such as hyperpyrexia, sleep disturbance or an eating disorder.

Postoperative treatment

Six patients received radiosurgery for residual tumors (3 with craniopharyngioma, 2 with pituitary adenoma, and 1 with mesenchymal tumor) 2–8 months after operation. Two patients with craniopharyngioma underwent a second operation due to tumor regrowth 5–12 months after the first operation. One patient underwent a second radiosurgery session for residual tumor 2 months after the second operation. Four patients (2 with craniopharyngioma, 1 with pituitary adenoma, and 1 with mesenchymal tumor) required endocrine replacement therapy for hypopituitarysm. However, these patients all already had primary or secondary pituitary hypofunction preoperatively.

Discussion

Several approaches to hypothalamic lesions have been developed [1, 2, 6, 9, 15, 20]. The choice in any one case depends on the size and the extent of the tumor. The pterional approach is used for tumors with lateral extension, the anterior temporal or orbitozygomatic approach is used for posterior extension beyond the dorsum sellae, and the transcallosal intraventricular approach is used for superior extension into the lateral ventricle. However, the best visualization of the hypothalamus may be obtained by the basal interhemispheric approach, because this approach provides both internal superior and external basal views of the hypothalamus. Most hypothalamic lesions compress the optic chiasm from below. The infrachiasmal approach allows a wide view of the suprasellar region. Both posterior communicating arteries, the III cranial nerves, the basilar bifurcation, the posterior cerebral arteries, and the superior cerebellar arteries are usually exposed, as are the floor of the III ventricle, the pituitary stalk and the crus cerebri, during the removal of tumors. Superomedial orbitotomy permits visualization of the floor of the III ventricle, the handling of long instruments from different angles, and sharp dissection under direct visualization without retraction of the hypothalamus.

Guidelines exists for the treatment of hypothalamic lesions, especially for craniopharyngiomas [3, 5, 14, 16]. Total removal without any hypothalamo-pituitary dysfunction is one of the goals of treatment and may be achieved in some patients. However, total resection is associated with significant morbidity, especially in patients with a large tumor. Although endocrine treatment can control hypopituitarism, problems may arise in areas such as sexual development and activities of daily living. Further, there is a persistent risk of sudden death due to endocrine crisis. These postoperative complications are especially important considerations in children and adolescents. On the basis of a retrospective analysis of peritumor tissue in surgical and autopsy specimens of craniopharyngioma patients [12, 18], we have concluded that total tumor removal, including hypothalamic invasion, is bound to cause hypothalamo-pituitary dysfunction. To preserve function, we concluded that tumors invading the hypothalamus should be left and be treated by a less invasive method (radiosurgery). In this series, 3 of 5 patients with craniopharyngioma did not require postoperative hormone replacement therapy. The girl with the huge craniopharyngioma, who was treated by radiosurgery after subtotal resection of the tumor, had normal sexual maturation after treatment. Although long-term follow-up studies are required, it is possible for these patients to have a normal life. Preservation of preoperative hypothalamo-pituitary function is a worthwhile goal even when some there is disturbance of function, compared with complete panhypopituitarism. Preservation of function is more likely in patients with a pituitary adenoma or meningioma than in those with a craniopharyngioma, because tumor adhesion and invasion of the hypothalamus and pituitary stalk are less frequent.

Rhinorrhea and meningitis are predictable complications of skull base surgery. Although 2 patients had rhinor-

rhea, no surgical treatment was required. No other complications resulting from the superomedial orbitotomy were found. Repair of the frontal sinus with fatty tissue, fibrin glue and pericranium appears sufficient protection against rhinorrhea. In young children, development of the frontal sinus is influenced by superomedial orbitotomy, as it is in patients with orbital advancement for craniosynostosis. Although no problems have been recognized to date, long-term follow-up studies may be required. Anosmia is a major complication of the frontal interhemispheric approach [7]. The basal interhemispheric approach with a unilateral dural incision effectively preserves olfactory function because retraction of the frontal lobe is minimal, as reported in aneurysm surgery [7]. No patient developed total anosmia in this series, even though exposure was more extensive than in aneurysm surgery. Extensive surgical experience and minimal brain retraction are essential for a favorable outcome.

Radiosurgery has been reported as a useful treatment for craniopharyngiomas, residual pituitary adenomas and cavernous sinus lesions [3, 4, 8, 11]. In this series, 6 patients were treated by a gamma unit for residual tumors in the hypothalamus, sella turcica and cavernous sinus. Although long-term follow-up is necessary, radiosurgery appears to preserve hypothalamo-pituitary function. Backlund et al. has reported long-term results of radiosurgery for craniopharyngioma, including preservation of endocrinologic functions [3, 17]. Development of radiosurgical techniques may provide less invasive treatment and better preservation of visual and hypothalamo-pituitary function for patients with hypothalamic lesions.

In conclusion, the basal interhemispheric supra- and/or infrachiasmal approach via superomedial orbitotomy provides better visualization of the hypothalamus. An internal view of the lateral wall and the floor of the III ventricle is possible with the suprachiasmal approach, and the pituitary stalk, optic tracts and the floor of the III ventricle are exposed by the infrachiasmal approach. Hypothalamo-pituitary function was preserved or unchanged in most patients with or without associated radiosurgery.

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