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CLINICAL ARTICLE - BRAIN TUMORS

Extended endoscopic endonasal approach for recurrent or residual adult craniopharyngiomas

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Abstract
Background The aim of this study was to evaluate the effectiveness of the extended endoscopic endonasal transsphenoidal approach (TSA) for recurrent or residual craniopharyngiomas, focusing on the extent of tumor resection and complications resulting from surgery at a single institution.
Methods Twelve adult patients (six men and six women) underwent extended endoscopic endonasal TSA for a recurrent or residual craniopharyngioma after a previous surgical intervention at a single institution by a single surgeon. The mean number of surgeries patients had undergone before TSA was 1.3 (range, 1–3). The mean period between patients' most recent surgery and extended TSA was 55.9 months (range, 1–184). The mean preoperative (that is, pre-extended TSA) tumor volume was 2.87 cm^3. The mean follow-up period was 15.8 months (range, 4–32). We reviewed clinical and radiological features in each case, focusing on the degree of tumor resection as well as endocrinological and ophthalmological outcomes.
Results Gross total resection was achieved in ten patients (83.3 %), and the mean resection rate was 87 % in the other two cases. There were no significant differences between pre- and postoperative endocrine function, except in one patient who suffered postoperative panhypopituitarism resulting in pituitary stalk resection, which was necessary because of obvious tumor involvement. Three patients suffered transient diabetic insipidus (DI). With respect to ophthalmological outcomes, three patients showed improvement, two others showed decline, and the remainder showed no significant changes.
Conclusion The extended endoscopic endonasal transsphenoidal approach is an effective and safe surgical approach for treating recurrent or residual craniopharyngioma.

Keywords Recurrent or residual · Craniopharyngioma · Extended TSA · Endoscopy

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Introduction

Craniopharyngiomas constitute between 2.5 and 4 % of all benign intracranial tumors. The tumors originate from the remnants of the hypophyseal pharyngeal duct or squamous epithelial rests [11, 18]. Craniopharyngiomas are most commonly located in the sellar and suprasellar areas, close to vital structures such as the hypothalamus and thalamus [11]. The tumors are locally aggressive, with a high rate of recurrence and regrowth. Therefore, craniopharyngiomas are considered semimalignant tumors and are recognized as challenging to treat despite their benign microscopic appearance [33, 36]. Generally, complete surgical removal of craniopharyngiomas is believed to achieve the most satisfactory results and has a low recurrence rate. However, complete resection is not always feasible because of the deep location of the tumors or their close proximity to vital neurovascular structures [28]. Moreover, despite radical excision, most studies have reported recurrence rates between 5 and 57 % [7, 37]. Treatment of recurrent or residual craniopharyngioma is important to achieve a good prognosis and long-term tumor control. Depending on tumor location and extent, various transcranial approaches have traditionally been used to treat craniopharyngioma, including the bifrontal, subfrontal and pterional approaches. Repeat surgery is more technically difficult than the first surgery and occasionally results in increased morbidity and mortality because of factors including tumor adherence at the surgical scar and brain retraction [30,

38]. The transsphenoidal approach (TSA) has also been performed using a microscopic or endoscopic device, though classically the technique has been limited to predominantly intrasellar or intrasuprasellar subdiaphragmatic lesions [13, 39]. Recently, the development and application of extended TSA makes it practicable to remove recurrent or residual craniopharyngiomas [3, 17]. We present a series of 12 cases in which patients were surgically treated using extended endoscopic endonasal TSA and suggest that the technique is feasible for treatment of recurrent or residual craniopharyngioma.

Materials and methods

Patients

After the approval for the retrospective analysis by the Institutional Review Board, the electronic medical records were reviewed from a total of 12 adult patients with recurrent or residual craniopharyngioma who had undergone surgery using extended endoscopic endonasal TSA by a single surgeon at our institution between August 2010 and June 2013. The patients included six males and six females between the ages of 25 and 62. All patients were treated using surgical intervention upon their initial diagnosis; the mean number of surgeries prior to the extended endoscopic endonasal TSA was 1.3. Of the 12 patients, 2 had undergone 2 previous surgeries, 1 had undergone 3 previous surgeries, and the remaining patients had undergone 1 surgery. The type of previous surgery was the transcranial approach in nine patients and endoscopic TSA in two patients, and the remaining patient had undergone two previous surgeries including both the transcranial approach and endoscopic TSA. After extended TSA, the mean follow-up period was 15.8 months, with a range of 4 to 32 months. Four patients also underwent adjuvant radiotherapy. Of the two patients for whom subtotal resection was achieved, one patient was not eligible for adjuvant treatment because of previous radiotherapy.

Clinical data for each patient were obtained by reviewing relevant medical records. Clinical information, including the extent of resection, stalk preservation, endocrinological and visual outcome, and postoperative complications were analyzed. Visual outcome was evaluated using a visual impairment score (VIS) according to the German Ophthalmological Society guidelines developed by Fahlbusch [8]. The VIS was calculated by translating the scores from specific tables based on visual acuity and visual field defects. Pre- and postoperative scores were added, and the sum values ranged from 0 (best) to 100 (worst). All 12 patients were given endocrine assessments both pre- and postoperatively. Complete serum pituitary hormone levels were evaluated, and the results were interpreted by an endocrinologist. Based on the endocrinological assessments, nine patients suffered from preoperative pituitary hormone dysfunctions. One patient had hypogonadism, and the others had preoperative panhypopituitarism of the anterior pituitary gland, with or without DI. Three patients had normal preoperative pituitary hormone function.

Neuroradiological assessment was performed using magnetic resonance imaging (MRI) both preoperatively and within 2 days following the operation. Preoperatively, MRI was used to classify the lesion location and type (predominantly cystic, solid or mixed). In total, there were five cystic, three solid and four mixed lesions. The degree of tumor resection was confirmed by assessing both intraoperative findings and postoperative MRI. Gross total resection was defined as the absence of residual tumor visible based on these assessments [7]. Subtotal resection was defined as any small residual tumor confirmed intraoperatively or postoperatively.

Patient characteristics and preoperative clinical data are reported in Table 1.

Surgical procedures

All surgeries were performed using the endoscopic endonasal trans-tubercular and trans-sellar approaches. An image-guided neuronavigation system was used to confirm anatomical details and to remove the skull base bone. The details of the operative technique and process were similar to those previously published in the literature [10, 19]. After opening the dura mater, we dissected a plane between the tumor capsule and arachnoid membrane to protect the optic apparatus, which is supplied by perforator vessels, such as the superior hypophyseal artery. Next, the pituitary stalk was identified by dissecting the tissue between the pituitary gland and tumor capsule; if the pituitary stalk was confirmed to have obvious tumor invasion, it was sacrificed. Sharp dissection was performed to protect the optic nerve, tract and hypothalamus. Liliequist's membrane was preserved if its integrity was confirmed. The reconstruction of the skull base bone was performed using various methods, including a nasoseptal pedicle flap [24].

Results

Total resection was accomplished in ten patients (83.3 %) and subtotal resection in two patients (16.7 %). In one case, severe adherence of the tumor to the posterior communicating artery prevented total resection; in the other, the arachnoid membrane was disrupted because of prior surgery, and there were severe adherences to the internal carotid artery and posterior communicating artery. The resection rate was calculated by comparing pre- and postoperative tumor volume. The overall

Table 1 Summary of patient data

Patient no.	Age (years)/ sex	Number of previous surgeries	Type of previous surgery	Follow-up duration	Recurrent or residual	Type	Preoperative hormonal status
1	41/M	2	1st Transcranial, 2nd endoscopic TSA	25	Recurrent	Cystic	Panhypopituitarism
2	40/M	1	Transcranial	14	Residual	Cystic	Panhypopituitarism
3	25/F	1	Transcranial	32	Residual	Cystic	Normal
4	62/M	1	Transcranial	31	Residual	Cystic	Normal
5	57/M	1	Transcranial	16	Recurrent	Mixed	Normal
6	61/M	3	All transcranial	6	Recurrent	Solid	Panhypopituitarism
7	38/F	1	Transcranial	20	Residual	Solid	Hypogonadism
8	46/F	1	Transcranial	11	Recurrent	Cystic	Panhypopituitarism
9	43/F	1	Endoscopic TSA	13	Recurrent	Mixed	Panhypopituitarism
10	27/M	1	Transcranial	8	Residual	Solid	Panhypopituitarism
11	62/F	1	Transcranial	10	Residual	Mixed	Panhypopitutiarism
12	59/F	2	All endoscopic TSA	4	Recurrent	Mixed	Panhypopituitarism

resection rate was 97.8 %. Among the subtotal resection cases, the average resection rate was 87 %.

In three of the cases for which total resection was achieved, patients underwent adjuvant treatment because of rapid recurrence after a previous surgery. The extent of resection and information related to post-TSA adjuvant treatment are summarized in Table 2.

Postoperative endocrinopathy results had a relationship with whether stalk preservation was achieved. The stalk was preserved in six patients; in three patients, the stalk was resected because of intraoperative discovery of tumor invasion. The stalks of the remaining three patients had been resected during a previous surgery; those patients all suffered from preoperative panhypopituitarism. The three patients who received stalk resection showed postoperative endocrine dysfunction. In two of those three patients, the pituitary stalk was preserved only anatomically, and those two patients showed preoperative panhypopituitarism. New onset endocrinopathy occurred in one patient. Of the patients with normal preoperative pituitary function, no one was diagnosed with permanent postoperative endocrinopathy; these patients had suffered from transient DI for several months.

The preoperative mean total VIS was 28.6; the postoperative value was 29.6. Of the 12 patients, 3 had improved, 2 had deteriorated, and the others had unchanged total VIS. Among the improved patients, the visual field had normalized in two patients, and visual acuity had improved in one patient. However, two patients suffered decreases in visual acuity; one patient's visual acuity VIS increased from 2 to 10, the other's from 4 to 35. Neither patient complained of significant

Table 2 The extent of resection and adjuvant treatment

Patient no.	Extent of resection	Tumor volume (cm^3)			Postoperative adjuvant treatment
		Pre-TSA	Post-TSA	Resection rate	
1	Total resection	0.96		100	RTx
2	Total resection	6.7		100	
3	Total resection	2.6		100	
4	Total resection	1.66		100	
5	Total resection	2.6		100	
6	Subtotal resection	2.88	0.5	82.6	
7	Total resection	0.18		100	
8	Subtotal resection	0.93	0.08	91.4	RTx
9	Total resection	2.15		100	RTx
10	Total resection	3.34		100	
11	Total resection	8.53		100	
12	Total resection	1.87		100	RTx

visual changes immediately after surgery, but showed signs of deterioration some days later. Both patients showed some improvement in visual acuity during follow-up.

Postoperative infection occurred in one patient, who suffered procedure-related fungal ventriculitis. The patient had preoperative panhypopituitarism and had undergone three previous operations (the most of all patients included in the study). The patient was also the only one to have undergone adjuvant radiotherapy before the extended TSA. There were no postoperative infections among the patients with normal preoperative pituitary function. We cannot entirely rule out the relationship between postoperative infection and the number of previous surgeries, preoperative hormonal status and prior adjuvant radiotherapy. There were no mortalities among the patients in the study, and no postoperative CSF leakage. The postoperative complications as well as endocrinological and visual outcomes are shown in Table 3.

Discussion

Tumor recurrence is a common event in the management of craniopharyngioma. However, there is some debate over the optimal treatment for recurrent or residual craniopharyngioma. After initial surgical intervention, recurrence rates between 9 % and 51 % have been reported [1, 14, 32]. Craniopharyngioma recurrence is considered a significant factor related to long-term mortality. Many studies have confirmed that the extent of resection is the most important predictor of recurrence [6, 7, 26, 32]. Reported recurrence rates are between 6 % and 20 % in cases of GTR and 10 % to 75 % in cases of STR. In GTR cases, the mean period to tumor recurrence was between 20 and 96 months; in the STR group, the value was between 3.5 and 7.1 months [1, 4, 6, 12, 27]. Total resection should be the initial goal when treating craniopharyngioma. However, total resection is not always possible because of the tumor's deep location or the involvement of neurovascular structures. Adjuvant radiotherapy, therefore, is employed as a combination therapy in patients with subtotal tumor resection. In cases of subtotal resection, it is generally accepted that postoperative radiotherapy reduces recurrence rates [30]. Therefore, some authors have emphasized the effectiveness of radiotherapy for treating recurrent or residual craniopharyngioma; a good long-term outcome, similar to that of gross total resection, has been reported [9, 14, 16, 29, 31]. If, after first line treatment using these modalities, tumor recurrence or progression of the residual tumor is observed, a second radiotherapy treatment is not possible because of the risk of mass effect-induced neuropathy. Moreover, if previous radiotherapy has not been administered as a first line treatment, surgical resection (when possible) for recurrent or residual craniopharyngioma reportedly results in good outcomes [27]. Surgical management of recurrent or residual craniopharyngioma is considered the appropriate choice.

Repeat transcranial surgery is recognized as more difficult than primary surgery. Many reports have indicated that repeat surgery results in lower total resection rates and higher postoperative mortality rates [2, 7, 35]. These results are due to the technical difficulties associated with repeat surgery; it is difficult to distinguish the natural cleavage plane in the presence of arachnoidal scars from prior surgery and the loss of a gliotic reaction between the tumor and the surrounding normal structures. Brain manipulation and severe adherence to surrounding vital organs, including the perforator vessels, optic

Table 3 Postoperative complications with endocrinologic and visual outcomes

Patient no.	Stalk	Postoperative hormonal status	Visual impairment score						Complications
			Pre			Post			
			VA	VF	Total	VA	VF	Total	
1	Save	No change	8	0	8	8	0	8	
2	Section	No change	4	0	4	4	0	4	
3	Save	No change	100	22	122	100	22	122	
4	Save	No change	2	0	2	10	0	10	
5	Save	No change	8	0	8	8	0	8	
6	Previous resected	No change	4	22	26	4	0	4	fungal ventriculitis
7	Section	Panhypopituitarism	4	0	4	35	5	40	
8	Previous resected	No change	0	4	4	0	0	0	
9	Save	No change	8	0	8	4	0	4	
10	Section	No change	100	0	100	100	0	100	
11	Previous resected	No change	35	0	35	35	0	35	
12	Save	No change	22	0	22	22	0	35	

apparatus, hypothalamus and thalamus, also make repeat surgery more challenging, resulting in higher morbidity and mortality.

Recently, treatment series analyzing craniopharyngioma using a pure endoscopic endonasal TSA have been reported [5, 10, 22, 23]. In the present study, we used a purely extended endoscopic endonasal TSA to remove only recurrent or residual craniopharyngioma. This helped avoid the risk of transcranial route revision via a virgin route. Furthermore, the technique is widely known to have advantages, such as providing a more direct view of the neurovascular structures of the suprasellar area without requiring brain retraction.

The most important factor related to the long-term outcome in craniopharyngioma patients is the extent of tumor resection. In our series, gross total resection was obtained in approximately 83 % of cases, without mortality. The overall resection rate was 87 % in cases of subtotal resection. Kitano and Taneda reported a total tumor removal rate of 85.7 % when treating recurrent craniopharyngioma using extended TSA; our data are consistent with those results [21]. A close correlation between the extent of resection and visual outcome has been reported in some studies [20, 34]. Patients who underwent subtotal resection were at risk of visual disturbance occurring during long-term follow-up [20]. In our study, there was no significant difference between pre- and postoperative visual impairment scores, except in one case.

It is generally known that postoperative CSF leakage occurs less frequently when using transcranial approaches. However, recently developed reconstruction techniques have reduced CSF leakage rates significantly, to approximately 0 % to 4 % [15, 24, 25]. There was a little difference in the reconstruction method adapted for each patient. The skull base of almost all patients was reconstructed using the hydroxyapatite cement paste after an autologous or artificial patch graft, which was covered by a nasoseptal pedicle flap. A button graft with fascia lata was applied in one patient, which was also followed by a nasoseptal pedicle flap. There were no cases of postoperative CSF leakage in our series, and only one patient suffered a postoperative infection.

The limitations of this study are its small number of patients and a short follow-up period. Larger studies with more extensive follow-up will help to establish the optimal role of extended TSA for recurrent or residual craniopharyngioma. Furthermore, the correlation between tumor size, location, tumor nature and individual anatomical features of the suprasellar area should be analyzed.

Conclusion

The extended endoscopic endonasal transsphenoidal approach is a safe and effective treatment option for recurrent or residual craniopharyngiomas that were initially treated surgically.

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Conflict of Interests None.

References

1. Bulow B, Attewell R, Hagmar L, Malmstrom P, Nordstrom CH, Erfurth EM (1998) Postoperative prognosis in craniopharyngioma with respect to cardiovascular mortality, survival, and tumor recurrence. J Clin Endocrinol Metab 83:3897–3904
2. Caldarelli M, di Rocco C, Papacci F, Colosimo C Jr (1998) Management of recurrent craniopharyngioma. Acta Neurochir 140: 447–454
3. Cavallo LM, Prevedello DM, Solari D, Gardner PA, Esposito F, Snyderman CH, Carrau RL, Kassam AB, Cappabianca P (2009) Extended endoscopic endonasal transsphenoidal approach for residual or recurrent craniopharyngiomas. J Neurosurg 111: 578–589
4. Chakrabarti I, Amar AP, Couldwell W, Weiss MH (2005) Long-term neurological, visual, and endocrine outcomes following transnasal resection of craniopharyngioma. J Neurosurg 102:650–657
5. de Divitiis E, Cavallo LM, Cappabianca P, Esposito F (2007) Extended endoscopic endonasal transsphenoidal approach for the removal of suprasellar tumors: Part 2. Neurosurgery 60:46–58, discussion 58-49
6. Duff J, Meyer FB, Ilstrup DM, Laws ER Jr, Schleck CD, Scheithauer BW (2000) Long-term outcomes for surgically resected craniopharyngiomas. Neurosurgery 46:291–302, discussion 302–295
7. Fahlbusch R, Honegger J, Paulus W, Huk W, Buchfelder M (1999) Surgical treatment of craniopharyngiomas: experience with 168 patients. J Neurosurg 90:237–250
8. Fahlbusch R, Schott W (2002) Pterional surgery of meningiomas of the tuberculum sellae and planum sphenoidale: surgical results with special consideration of ophthalmological and endocrinological outcomes. J Neurosurg 96:235–243
9. Fischer EG, Welch K, Shillito J Jr, Winston KR, Tarbell NJ (1990) Craniopharyngiomas in children. Long-term effects of conservative surgical procedures combined with radiation therapy. J Neurosurg 73: 534–540
10. Frank G, Pasquini E, Doglietto F, Mazzatenta D, Sciarretta V, Farneti G, Calbucci F (2006) The endoscopic extended transsphenoidal approach for craniopharyngiomas. Neurosurgery 59:ONS75–ONS83, discussion ONS75-83
11. Fuller GN, Scheithauer BW (2007) The 2007 Revised World Health Organization (WHO) Classification of Tumours of the Central Nervous System: newly codified entities. Brain Pathol 17:304–307
12. Gupta DK, Ojha BK, Sarkar C, Mahapatra AK, Mehta VS (2006) Recurrence in craniopharyngiomas: analysis of clinical and histological features. J Clin Neurosci: Off J Neurosurg Soc Australas 13:438–442
13. Honegger J, Buchfelder M, Fahlbusch R, Daubler B, Dorr HG (1992) Transsphenoidal microsurgery for craniopharyngioma. Surg Neurol 37:189–196
14. Isaac MA, Hahn SS, Kim JA, Bogart JA, Chung CT (2001) Management of craniopharyngioma. Cancer J 7:516–520
15. Jane JA Jr, Kiehna E, Payne SC, Early SV, Laws ER Jr (2010) Early outcomes of endoscopic transsphenoidal surgery for adult craniopharyngiomas. Neurosurg Focus 28:E9
16. Jose CC, Rajan B, Ashley S, Marsh H, Brada M (1992) Radiotherapy for the treatment of recurrent craniopharyngioma. Clin Oncol 4:287–289

17. Kaptain GJ, Vincent DA, Sheehan JP, Laws ER Jr (2008) Transsphenoidal approaches for the extracapsular resection of midline suprasellar and anterior cranial base lesions. Neurosurgery 62: 1264–1271
18. Karavitaki N, Cudlip S, Adams CB, Wass JA (2006) Craniopharyngiomas. Endocr Rev 27:371–397
19. Kassam AB, Gardner PA, Snyderman CH, Carrau RL, Mintz AH, Prevedello DM (2008) Expanded endonasal approach, a fully endoscopic transnasal approach for the resection of midline suprasellar craniopharyngiomas: a new classification based on the infundibulum. J Neurosurg 108:715–728
20. Kim YH, Kim CY, Kim JW, Kim YH, Han JH, Park CK, Paek SH, Oh CW, Kim DG, Jung HW (2012) Longitudinal analysis of visual outcomes after surgical treatment of adult craniopharyngiomas. Neurosurgery 71:715–721
21. Kitano M, Taneda M (2009) Extended transsphenoidal surgery for suprasellar craniopharyngiomas: infrachiasmatic radical resection combined with or without a suprachiasmatic trans-lamina terminalis approach. Surg Neurol 71:290–298, discussion 298
22. Koutourousiou M, Gardner PA, Fernandez-Miranda JC, Tyler-Kabara EC, Wang EW, Snyderman CH (2013) Endoscopic endonasal surgery for craniopharyngiomas: surgical outcome in 64 patients. J Neurosurg 119:1194–1207
23. Laufer I, Anand VK, Schwartz TH (2007) Endoscopic, endonasal extended transsphenoidal, transplanum transtuberculum approach for resection of suprasellar lesions. J Neurosurg 106:400–406
24. Leng LZ, Brown S, Anand VK, Schwartz TH (2008) "Gasket-seal" watertight closure in minimal-access endoscopic cranial base surgery. Neurosurgery 62:ONSE342–ONSE343
25. Leng LZ, Greenfield JP, Souweidane MM, Anand VK, Schwartz TH (2012) Endoscopic, endonasal resection of craniopharyngiomas: analysis of outcome including extent of resection, cerebrospinal fluid leak, return to preoperative productivity, and body mass index. Neurosurgery 70:110–123, discussion 123–114
26. Maira G, Anile C, Rossi GF, Colosimo C (1995) Surgical treatment of craniopharyngiomas: an evaluation of the transsphenoidal and pterional approaches. Neurosurgery 36:715–724
27. Minamida Y, Mikami T, Hashi K, Houkin K (2005) Surgical management of the recurrence and regrowth of craniopharyngiomas. J Neurosurg 103:224–232
28. Puget S, Garnett M, Wray A, Grill J, Habrand JL, Bodaert N, Zerah M, Bezerra M, Renier D, Pierre-Kahn A, Sainte-Rose C (2007) Pediatric craniopharyngiomas: classification and treatment according to the degree of hypothalamic involvement. J Neurosurg 106:3–12
29. Regine WF, Mohiuddin M, Kramer S (1993) Long-term results of pediatric and adult craniopharyngiomas treated with combined surgery and radiation. Radiother Oncol: J Eur Soc Ther Radiol Oncol 27:13–21
30. Samii M, Tatagiba M (1997) Surgical management of craniopharyngiomas: a review. Neurol Med Chir 37:141–149
31. Scott RM, Hetelekidis S, Barnes PD, Goumnerova L, Tarbell NJ (1994) Surgery, radiation, and combination therapy in the treatment of childhood craniopharyngioma–a 20-year experience. Pediatr Neurosurg 21(Suppl 1):75–81
32. Shi XE, Wu B, Zhou ZQ, Fan T, Zhang YL (2006) Microsurgical treatment of craniopharyngiomas: report of 284 patients. Chin Med J 119:1653–1663
33. Sorva R, Jaaskinen J, Heiskanen O, Perheentupa J (1988) Postoperative computed tomographic control of 38 patients with craniopharyngioma. Surg Neurol 29:115–119
34. Sughrue ME, Yang I, Kane AJ, Fang S, Clark AJ, Aranda D, Barani IJ, Parsa AT (2011) Endocrinologic, neurologic, and visual morbidity after treatment for craniopharyngioma. J Neuro-Oncol 101:463–476
35. Van Effenterre R, Boch AL (2002) Craniopharyngioma in adults and children: a study of 122 surgical cases. J Neurosurg 97:3–11
36. Wang KC, Hong SH, Kim SK, Cho BK (2005) Origin of craniopharyngiomas: implication on the growth pattern. Child's Nerv Syst: ChNS: Off J Int Soc Pediatr Neurosurg 21:628–634
37. Weiner HL, Wisoff JH, Rosenberg ME, Kupersmith MJ, Cohen H, Zagzag D, Shiminski-Maher T, Flamm ES, Epstein FJ, Miller DC (1994) Craniopharyngiomas: a clinicopathological analysis of factors predictive of recurrence and functional outcome. Neurosurgery 35: 1001–1010, discussion 1010–1001
38. Wisoff JH (1994) Surgical management of recurrent craniopharyngiomas. Pediatr Neurosurg 21(Suppl 1):108–113
39. Yasargil MG, Curcic M, Kis M, Siegenthaler G, Teddy PJ, Roth P (1990) Total removal of craniopharyngiomas. Approaches and long-term results in 144 patients. J Neurosurg 73:3–11

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