Arq Neuropsiquiatr 2005;63(1):40-45

INTRINSIC TECTAL LOW GRADE ASTROCYTOMAS

IS SURGICAL REMOVAL AN ALTERNATIVE TREATMENT?

Long-term outcome of eight cases

Ricardo Ramina[1,2], Mauricio Coelho Neto[1], Yvens Barbosa Fernandes[2], Guilherme Borges[2], Donizeti Cesar Honorato[2], Walter Oleschko Arruda[1,3]

ABSTRACT - Low-grade gliomas arising in dorsal midbrain in children and young patients usually present few neurological symptoms and findings, and patients´ management is controversial. Some authors propose only clinical observation until the patient present signs of increased intracranial pressure when a shunt with or without biopsy, is inserted; others recommend radiotherapy after stereotactic or open biopsy. Microsurgical total removal of tumor may be curative. We present a retrospective analysis of eight patients (mean age 16.6 ±11.5 years-old) with low-grade astrocytoma of the tectal region operated on using an infratentorial/ supracerebellar approach between 1981 and 2002. All patients presented hydrocephalus and had a shunt insertion before surgical resection of the lesion. The tumour could be totally resected in seven patients. In one case radical removal was not possible due to infiltrative pattern of the lesion. Postoperative radiotherapy was performed in two cases, one patient at the beginning of this series and in the case with infiltrative tumor. This patient presented progressive tumor growth and died five years after surgery. No recurrence occurred after total removal. Post-surgical follow-up time ranged from 2 1/2 to 22 1/2 years (mean 9.9 ± 5.9 years). Radical microsurgical removal of non invasive tumors is possible without mortality or significant morbidity. It may be curative and should remain as an alternative to be discussed with the patient.

KEY WORDS: astrocytoma, tectal tumours, glioma, hydrocephalus.

Astrocitomas tectais de baixo grau: o tratamento cirúrgico é uma alternativa? análise de oito casos com longa evolução

RESUMO - Gliomas de baixo grau originários da porção dorsal do mesencéfalo ocorrem em crianças e adultos jovens. Geralmente apresentam pouca sintomatologia e tardia, com hipertensão intracraniana por hidrocefalia não-comunicante. O seu tratamento é controverso. Alguns autores propõem somente observação clínica até o aparecimento de sintomas decorrentes de hipertensão intracraniana, quando é realizada derivação ventrículo-peritoneal (DVP), com ou sem biópsia da lesão. Outros recomendam radioterapia após comprovação histológica por biópsia estereotáxica. A remoção cirúrgica total pode ser curativa. Analisamos retrospectivamente 8 pacientes com astrocitoma de baixo grau na região tectal operados entre 1981 e 2002. A idade média foi 16,6 ±11,5 anos (variando de 8 a 44 anos). As lesões foram abordadas por acesso infratentorial / supra-cerebelar. Todos os pacientes apresentaram hidrocefalia e uma DVP foi colocada em todos antes da remoção cirúrgica da lesão. A lesão tumoral foi removida completamente em 7 dos 8 casos. Em um único caso a remoção total foi impossível devido ao caráter infiltrativo do tumor. Radioterapia pós-operatória foi indicada em 2 casos, o primeiro no início da série e o segundo caso com tumor de caráter infiltrativo. Este último paciente apresentou crescimento tumoral progressivo e veio a falecer 5 anos após a cirurgia. Nos demais 7 pacientes não houve recurrência tumoral. O tempo de acompanhamento foi 2,5 a 22,5 anos (média 9,9 ± 5,9 anos). Remoção microneurocirúrgica radical pode e deve ser sempre cogitada em pacientes com tumores não-invasivos, pois a baixa morbi/mortalidade é possível e aceitável, além do procedimento poder ser curativo.

PALAVRAS-CHAVE: astrocitoma, tumores tectais, glioma, hidrocefalia.

[1]Instituto de Neurologia de Curitiba, Curitiba PR, Brasil; [2]Departamento de Neurocirurgia, da Universidade Estadual de Campinas (UNICAMP), Campinas SP, Brazil; [3]Professor assistente de Neurologia, Universidade Federal do Paraná, Curitiba PR, Brasil.

Received 15 July 2004. Accepted 12 October 2004.

Dr. Ricardo Ramina - Rua Gonçalves Dias 713 - 80340-240 Curitiba PR - Brasil. E-mail: ramina@bsi.com.br

Surgical resection of brain stem tumours is currently limited to dorsal exophytic tumours arising from the floor of the fourth ventricle and some intrinsic lesions of the cervicomedullary junction and midbrain[1]. Radiotherapy and chemotherapy remain alternative therapies for other infiltrative and biologically aggressive brainstem tumours. Long-term prognosis is usually very poor[2]. Low-grade astrocytomas of the tectal region present characteristic neuroradiological findings (specially in the MRI examination) and are often slow growing lesions causing late-onset aqueductal stenosis and hydrocephalus[3].

Due to this indolent growth and few clinical symptoms the management of these lesions remains controversial[1,3-7]. Some authors recommend only a shunt procedure and clinical observation[3,8,9], others indicate biopsy and radiotherapy[10-12] and in some centres radical surgery has been performed[1,5,13,14].

We reviewed our experience with eight patients harbouring intrinsic tectal low-grade astrocytomas.

METHOD

Between 1981 and 2002, eight patients (six males and two females) with low-grade astrocytomas of the tectal plate were operated on in the Instituto de Neurologia de Curitiba (Table 1). Seven patients were younger than 20 years and only one was older than 40 years (mean age 16.6±11.5 years-old). During this period of time, 43 pineal region tumors were surgically removed. All patients complained of headache, nausea and vomiting for several months. Three patients had papilledema. Two patients presented Parinaud's syndrome and one was referred with the diagnosis of communicating hydrocephalus with no tumor visible in a high definition contrast enhanced computerized tomography (CT) examination. One patient had a ventricle-peritoneal shunt surgery 33 years before admission due to communicating hydrocephalus. She presented headache and Parinaud's syndrome and magnetic resonance image (MRI) examination revealed a lesion in the tectal region. All patients presented hydrocephalus, focal calcification in the pineal region was seen in two cases and contrast enhancement in the pineal and tectal region was observed in two patients. The first patient of this series had only CT scan which showed a enhanc-

Table 1. Clinical and radiological findings.

Case	Age (years)	Clinical	CT presentation	MRI
1	14	Headache, diplopia	Tectal mass, hydrocepahlus	Not done
2	8	Parinaud syndrome, headache, diplopia	Focal calcification, hydrocephalus	Tectal mass
3	11	ICPS	Hydrocephalus	Tectal mass
4	9	ICPS	Hydrocephalus	Tectal mass
5	13	ICPS	Calcification hydrocephalus	Tectal mass
6	17	ICPS	Hydrocephalus	Tectal mass
7	17	ICPS, Parinaud Syndrome	Hydrocephalus	Tectal mass
8	44	Headache, diplopia	Previous shunt	Tectal mass

ICPS, increased intracranial pressure syndrome (headache, vomiting and papilledema).

Table 2. Treatment and outcome.

Case	Follow-up (years)	Approach	Tumor removal	Complications	Radiotherapy
1	22 1/2	SC/IT	total	none	5.5 Gy
2	5	SC/IT	sub-total	none	5.5 Gy*
3	10 1/2	SC/IT	total	VI CN palsy**	no
4	10 1/2	SC/IT	total	PS**	no
5	10 1/2	SC/IT	total	none	no
6	10 1/2	SC/IT	total	PS**	no
7	7 1/2	SC/IT	total	none	no
8	2 1/2	SC/IT	total	VI CN palsy** PS**	no

SC/IT, supracerebellar/infratentorial; PS, Parinaud´s Syndrome; *Tumor recurrence; **Transient.

ing tectal tumor. The other patients underwent (MRI) examination with and without gadolinium administration. The patients studied with MRI presented, in the tectal region, an iso or hypointense mass on T1- weighted studies and hyperintense on T2-weighted images. No enhancement or edema around the lesion were observed.

Hydrocephalus was treated with shunt procedure (seven patients) and endoscopic third ventriculostomy (one case). Tumor removal was performed through an infratentorial/ supracerebellar approach in a modified "concorde position". The first patient in this series was irradiated (6 Mv linear accelerator, 5500 cGy) and presented memory impairment probably related to radiotherapy. One patient with recurrent infiltrative astrocytoma received postoperative radiotherapy. Control neurological examination and MRI- examinations were performed (annually) in all cases between 2 1/2 and 22 1/2 years (mean 9.9 ± 5.9 years) after operation.

RESULTS

There were no complications related to the shunt placement or third ventriculostomy in this series. Hydrocephalus resolved in all patients. In the postoperative period, three patients presented incomplete Parinaud's syndrome, which disappeared completely three to six months after surgery. The two patients with preoperative Parinaud's syndrome showed marked improvement of the upward gaze after the operation. Radical tumor removal was possible in seven patients. Total tumor removal of the lesion was confirmed by MRI in seven cases. Sub-total tumor removal, due to infiltration of the brainstem (a small portion in the cerebral peduncle remained), was performed in one patient. Growth of this residual tumour was observed in MRI 3 years after operation. The tumor progressed and the patient died five years after surgery in spite of radiotherapy. There was no major complications in this series, three patients presented postoperative transient abducens palsy, which completely resolved within 3 and 6 months after surgery. No sign of tumor recurrence was observed in the follow-up examination of the remained seven patients. Histological diagnosis of all patients was low grade astrocytoma. A summary of treatment and outcome is presented in Table 2.

ILUSTRATIVE CASES

Case 1 – This 13-year-old boy presented to our clinic with a 6 months history of headache and vomiting. Neurological examination showed no abnormalities. CT scan examination showed hydrocephalus but no tumor even after contrast injection. A shunt was inserted and the symptoms disappeared. MRI performed 6 months after the shunt demonstrated a no enhancing tumor in the tectal region (Fig 1). The lesion was totally removed through a supracerebellar/infratentorial approach. Postoperative the patient developed Parinaud's syndrome that completely resolved in four months after operation. The histological diagnosis was low-grade astrocytoma. The patient remained asymptomatic and no tumor recurrence was observed in the control MRI 10 years after surgery (Fig1).

Case 2 – This 17-year-old boy started to complain of headache and diplopia, 8 months before admission to our clinic. The neurological examination revealed Parinaud's syndrome. MRI revealed hydrocephalus due to aqueduct occlusion by a tectal tumor. The lesion showed no contrast enhancement (Fig 2). A shunt was inserted and the tumor totally removed through a supracerebellar/infratentorial. The postoperative course was uneventful. The histopathological examination revealed a low-grade astrocytoma. A control MRI examination 7 years after operation showed no tumor recurrence (Fig 2).

Case 3 – This 44-year-old woman had a history of hydrocephalus treated by shunt placement 33 years before admission to our clinic. Several CT-scan examinations and two MRI showed normal ventricles and no tumor. Two months before admission to our clinic she presented symptoms of headache and diplopia and Parinaud's syndrome. MRI revealed a non-enhancing tumor in the tectal region (Fig 3). The lesion could be radically removed through a supracerebellar/infratentorial approach. There was no postoperative complication and the Parinaud's syndrome disappear completely 6 months after operation. The histological diagnosis was low-grade astrocytoma. The patient remained asymptomatic and a MRI, 2 years after surgery, showed total removal of the lesion (Fig 3).

DISCUSSION

Gliomas of the tectal plate are rare lesions. In a review of 486 brain tumors in children, only 6 cases were observed[10]. They may also occur in adults but are rare and corresponded to 8% in a series of 48 brain stem tumors[15]. These tumors are silent presenting very often only late-onset aqueduct stenosis and hydrocephalus[3,16,17]. The diagnosis of low-grade astrocytomas of the tectal region was difficult until the advent of MRI[18]. CT-scan may fail to reveal these tumors, for they may be isodense and non-enhancing. Therefore all patients with aqueduct stenosis should be investigated with MRI. MRI examination of these low-grade astrocytomas led to earlier diagnosis and they can be followed without invasive techniques[19]. Low-grade astrocytomas of this region typically present as isointense or hypointense lesions on T1-weighted images compa-

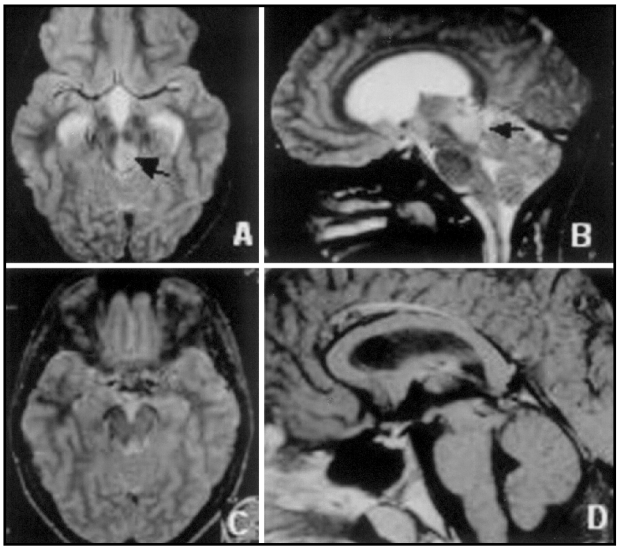

Fig 1. Preoperative T2-weighted MRI (A, B) tumor (black arrows). Postoperative MRI (C, D) 10 1/2 years after surgery showing total removal.

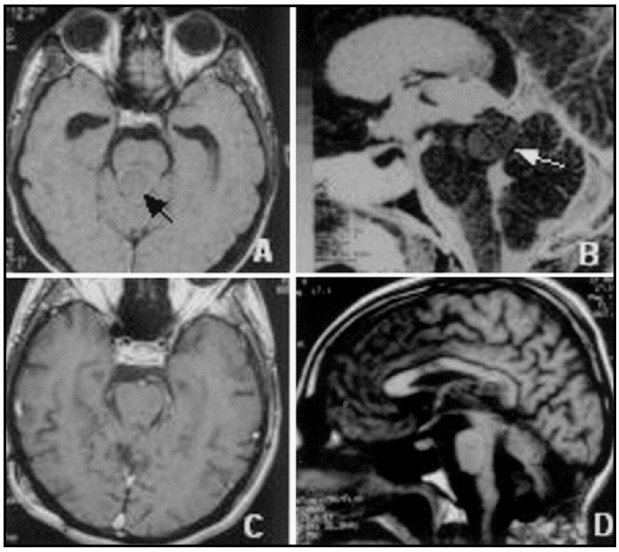

Fig 2. A, B - Preoperative MRI with gadolinium showing no enhancement (arrows). C, D - Postoperative MRI 7 1/2 years after surgery demonstrating total tumor removal.

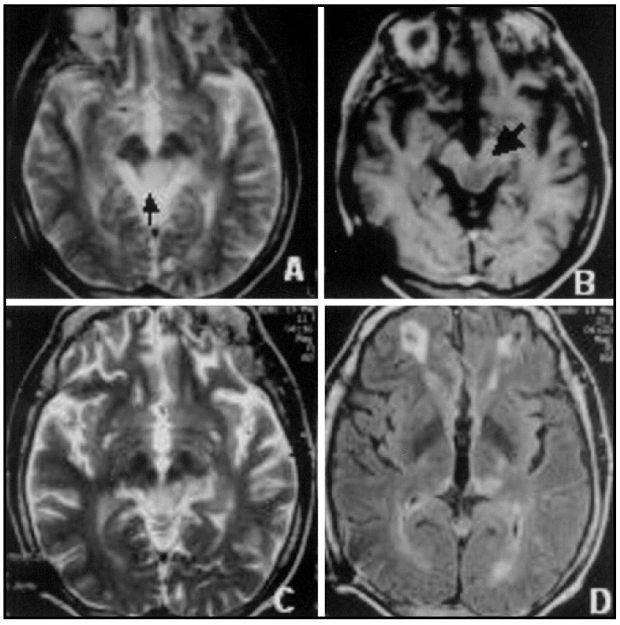

Fig 3. A, B - Preoperative T2 and T1- weighted MRI showing the tumor (arrow). C, D - Postoperative MRI (T2 weighted) 2 1/2 years after surgery showing total removal.

red to the surrounding brain and hyperintense in T2-weighted images. Tectus enlargement is characteristic[20,21] and gadolinium enhancement is not always observed. The natural history of these lesions is not well known and the choice of the best therapeutic approach is still controversial[3,5,6,20,22-26]. In a series of 16 patients, 4 cases demonstrated clinical signs of tumor progression (Parinaud's syndrome) with a median interval of 11.5 years from onset of initial symptoms and hydrocephalus[27]. Two cases of spontaneous tumor involution after third ventriculostomy were reported[28] Daglioglu et al.[29] conclude that intrinsic tectal gliomas of childhood which are less than 2 cm in diameter, without any tumor extension or contrast enhancement, should be managed conservatively.

The treatment of these patients varies from clinical observation with control MRI examinations to radical surgical removal. Increase of intracranial pressure due to hydrocephalus is the most common symptom of these patients. Shunt-procedures are indicated for hydrocephalus due to aqueductal stenosis [8,12]. Radical removal and/or radiotherapy for these benign lesions are usually indicated when radiological or clinical signs of tumor progression is observed[11,14]. Total tumor resection is possible with low morbidity[5,30]. Recently, Pollack et al. recommended biopsy and radiotherapy for patients with progressing symptoms [27]. Biopsy may be performed with neuroendoscopic techniques[31]. A biopsy may, however, produce sampling error and has some risks. The proliferate index studies with Ki-67 labelling is proving to be a valuable tool to confirm the aggressive behaviour of some astrocytic lesions[32] but their routine use as a prognostic index still need to be established.

Radical surgical removal is possible in non infiltrative lesions with no mortality and low morbid-

ity, it has two main advantages: confirm the diagnosis and may cure the patient. The approach used in this series, was the infratentorial/supracerebellar in a modified "concorde position"[33]. There is no clear evidence of beneficial effect of radiotherapy (radiosurgery) for low-grade astrocytomas. Routine use of radiotherapy or chemotherapy is questionable[21]. In a series of seven patients harbouring low-grade tectal gliomas treated with stereotatic radiosurgery, two developed severe radio-induced edema, one with permanent deficits and one did not respond to that treatment[34]. Radiation therapy should be avoided in children because it may cause anaplastic transformation of low-grade astrocytomas[35,36]. Tarlov[37] first suggested this complication in 1937 and development of radiation-induced tumours in other areas has been also reported[38-40]. Other deleterious effects of radiotherapy as psychomotor impairment, cranial neuropathy, leukoencephalopathy, endocrinopathy and vasculopathy have been also described[24, 41-47]. When an infiltrative pattern is present, a subtotal resection might be done to reduce morbidity. The efficacy of radiotherapy for incompletely resected low-grade astrocytomas remains to be proven[48,49]. The optimal management of high-grade astrocytomas of this region is unclear too. Attempt of radical surgery in patients with high-grade infiltrative lesions may produce severe postoperative neurological deficits. If gross total removal is, however, possible and followed by radio and chemotherapy, the prognosis of these patients is better[50].

In conclusion, low-grade astrocytomas of the tectal region have an indolent clinical course. Most of these lesions are truly focal neoplasms with little tendency to infiltrate surrounding structures. Headache, hydrocephalus and Parinaud´s syndrome are the most common symptoms. Some tumors may suffer transformation to higher grades. Hydrocephalus should be treated by shunt insertion or endoscopic third ventriculostomy. Radical removal of the lesion is possible in the majority of patients, may be curative and present very few complications. Surgical removal should be presented to the patient as a possibility of treatment, specially in growing low-grade tumors.

REFERENCES

1. Epstein F, McClearly EL. Intrinsic brain-stem tumours of childhood: surgical indications. J Neurosurg 1986;64:11-15.
2. Grigsby PW, Thomas PR, Schwartz HG, Fineberg BB. Multivariant analysis of prognostic factors in pediatric and adult thalamic and brainstem tumours. Int J Radiat Oncol 1989;16:649-655.
3. May PL, Blaser SI, Hoffman HJ, Humphreys RP, Harwood-Nash DC. Benign intrinsic tectal "tumours"in children. J Neurosurg 1991;74:867-871.
4. Albright AL, Guthkelch AN, Packer RJ, Price RA, Rourke LB. Prognostic factors in pediatric brain-stem gliomas. J Neurosurg 1986;65:751-755.
5. Lapras C, Bognar L, Turjman F, et al. Tectal plate gliomas: Part I. microsurgery of the tectal plate gliomas. Acta Neurochir (Wien) 1994;126:76-83.
6. Parker RJ, Nicholson HS, Vezina LG, Johnson DL. Brainstem gliomas. in Berger MS (ed). Neurosurg clinic, vol.3. Philadelphia: Saunders, 1992:863-879.
7. Yeh DD, Warnick RE, Ernst RJ. Management strategy for adult patients with dorsal midbrain gliomas. Neurosurgery 2002;50:735-740.
8. Gomez-Gosalvez FA, Menor F, Morant A, et al. Tectal tumours in paediatrics: a review of eight patients. Rev Neurol 2001;33:605-661.
9. Stroink AR, Hoffmann HJ, Hendrick EB, Humphreys RP. Diagnosis and management of pediatric brainstem gliomas. J Neurosurg 1986;65:745-750.
10. Boydston WR, Sanford RA, Muhlbauer MS, et al. Gliomas of the tectum and periaqueductal region of the mesencephalon. Pediatr Neurosurg 1992;17:234-238.
11. Robertson PL, Muraszko KM, Brunberg JA, Axtell RA, Dauser RC, Turrisi AT. Pediatric midbrain tumours: a benign subgroup of brainstem gliomas. Pediatr Neurosurg 1995;22:65-73.
12. Squires LA, Allen JC, Abbott R, Epstein FJ. Focal tectal tumours: management and prognosis. Neurology 1994;44:953-956 .
13. Heffez DS, Zinreich SJ, Long DM. Surgical resection of intrinsic brain stem lesions: an overview. Neurosurgery 1990;27:789-798.
14. Poussaint TY, Kowal JR, Barnes PD, et al. Tectal tumours of childhood: clinical and imaging follow-up. Am J Neuroradiol 1998;19:977-983.
15. Guillamo JS, Monjour A, Taillandier L, et al. Brainstem gliomas in adults: prognostic factors and classification. Brain 2001;124:2528-2539.
16. Panitch HS, Berg BO. Brainstem tumours of childhood and adolescence. Am J Dis Child 1970;119:465-472.
17. Vandertop WP, Hoffman HJ, Drake JM, et al. Focal midbrain tumours in children. Neurosurgery 1992;31:186-192.
18. Yoshida Y, Kitakami A, Kikuchi Y, Hidaka T, Ogawa A. Two surgical cases of tectal glioma. No Shinkei Geka 1995;23:705-709.
19. Smith RR, Zimmerman RA, Packer RJ, et al. Pediatric brainstem glioma; post-radiation clinical and radiographic follow-up. Neuroradiology 1990;32:265-271.
20. Bowers DC, Georgiades C, Aronson LJ, et al. Tectal gliomas: natural history of an indolent lesion in pediatric patients. Pediatr Neurosurg 2000;32:24-29.
21. Hamilton MG, Lauryssen C, Hagen N. Focal midbrain glioma: long term survival in a cohort of 16 patients and the implications for management. Can J Neurol Sci 1996;23:204-207.
22. Chapman PH. Indolent gliomas of the midbrain tectum, In Marlin AE (ed): Concepts in pediatric neurosurgery, vol.10. Basel: Karger, 1990;97-107.
23. Grant GA, Avellino AM, Loeser JD, Ellenbogen RG, Berger MS, Roberts TS. Management of intrinsic gliomas of the tectal plate in children. A ten-year review. Pediatr Neurosurg 1999;31:170-176.
24. Parker RJ, Zimmerman RA, Bilaniuk LT, et al. Magnetic resonance imaging in the evaluation of treatment-related central nervous system damage. Cancer 1986;58:635-640.
25. Pollack IF, Hoffman HJ, Humphreys RP, Bwcker L. The long-term outcome after surgical treatment of dorsally exophytic brain-stem gliomas. J Neurosurg 1993;78:859-863.
26. Vertosick FT Jr, Selker RG, Arena VC Survival of patients with well-differentiated astrocytomas diagnosed in the era of computed tomography. Neurosurgery 1991;28:496-501.
27. Pollack IF, Pang D, Albright AL. The long-term outcome in children with late-onset aqueductal stenosis resulting from benign intrinsic tectal tumours. J Neurosurg 1994;80:81-84.
28. Alkahani AM, Boop FA, Rutka JT. Involution of enhancing intrinsic tectal after endoscopic third ventriculostomy. Report of two cases. J Neurosurg 1999;91:863-869.
29. Daglioglu E, Cataltepe O, Akalan N. Tectal gliomas in children: the implications for natural history and management strategy. Pediatr Neurosurg 2003;38:223-231.
30. Kaku Y, Yokenawa Y, Taub E. Transcollicular approach to intrinsic tectal lesions. Neurosurgery 1999,44:338-344.
31. Mizoguchi M, Inamura T, Hikita T, Cheng CL, Ohgami S. Neuroendoscopic biopsy of tectal glioma: a case report. Minim Invasive Neurosurg 2000;43:53-55.
32. Sallinen PK, Sallinen SL, Helen PT, et al. Grading of diffusely infiltrating astrocytomas by quantitative histopathology, cell proliferation and image cytometric DNA analysis: comparison of 133 tumours in the context of the WHO 1979 and WHO 1993 grading schemes. Neuropathol Appl Neurobiol 2000;26:319-331.

33. Stein BM Surgical treatment of pineal tumours. Clin Neurosurg 1979;26:490-510.
34. Kihlstrom L, Lindquist C, Lindquist M, Karlsson B. Stereotactic radiosurgery for tectal low-grade gliomas. Acta Neurochir (Wien) 1994;62:55-57.
35. Dirks PB, Jay V, Becker LE, et al. Development of anaplastic changes in low-grade astrocytomas of childhood. Neurosurgery 1994;34:68-78.
36. Shapiro K, Katz M The recurrent cerebellar astrocytoma. Childs Brain 1983;10:168-176.
37. Tarlov IM. Effect of roentgenotherapy on gliomas. Arch Neurol Psychiatry 1937;38:513-536.
38. Kumar PP, Good RR, Skultety FM, Leibrock LG, Severson GS. Radiation-induced neoplasms of the brain. Cancer 1987;59:1274-1282.
39. Liwnicz BH, Berger TS, Liwnicz RG, Aron BS. Radiation-associated gliomas: report of four cases and analysis of postradiation tumours of the central nervous system. Neurosurgery 1985;17:436-445.
40. Ron E, Modan B, Boice JD, et al. Tumours of the brain and nervous system after radiotherapy in childhood. N Engl J Med 1988;319:1033-1039.
41. Donahue B. Short and long-term complications of radiation therapy for pediatric brain tumours. Pediatr Neurosurg 1992;18:207-217.
42. Duffner PK, Cohen ME, Voorhess ML, et al. Long-term effects of cranial irradiation on endocrine function in children with brain tumours. A prospective study. Cancer 1985;56:2189-2193.
43. Ellenberg L, McComb JG, Siegel SE, et al. Factors affecting intellectual outcome in pediatric brain tumour patients. Neurosurgery 1987;21:638-644.
44. Murros KE, Toole JF. The effect of radiation on carotid arteries. Arch Neurol 1989;46:449-455.
45. Parsons JT, Fitzgerald CR, Hood CI, Ellingwood KE, Bova FJ, Million RR. The effects of irradiation on the eye and optic nerve. Int J Radiat Oncol Biol Phys 1983;9:609-622.
46. Scanlon PW, Taylor WF. Radiotherapy of intracranial astrocytomas: analysis of 417 cases treated from 1960 through 1969. Neurosurgery 1979;5:301-308.
47. Tomita T. Long-term effects of treatment for childhood brain tumous, In Berger MS (ed): Neurosurg Clin N Am, vol. 3. Philadelphia: Saunders, 1992:959-968.
48. Hoffman H, Soloniuk DS, Humphreys RP, et al. Management and outcome of low-grade astrocytomas of the midline in children: a retrospective review. Neurosurgery 1993;33:964-970.
49. Pollack IF, Claassen D, Al-Shboul Q, Janosky JE, Deutsch M. Low-grade gliomas of the cerebral hemispheres in children: an analysis of 71 cases. J Neurosurg 1995;82:536-547.
50. Campbell JW, Pollack IF, Martinez AJ, Shultz B. High-grade astrocytomas in children: radiologically complete resection is associated with an excellent long-term prognosis. Neurosurgery 1996;38:258-264.