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Results of surgical treatment of anterior clinoidal meningiomas – our experiences



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ABSTRACT

Objective: Presentation of our experience in the treatment of anterior clinoidal meningiomas, including evaluation of factors that may affect early and long-term treatment outcomes.

Methods: Thirty patients were operated with strategy of complete tumor resection using fronto-orbito-zygomatic approach. Outcomes were assessed by Glasgow Outcome Scale at discharge and by Karnofsky Performance Scale at follow-up.

Results: There were 6 tumors in group I, 20 in group II, and 4 in group III according to Al-Mefty classification. Complete tumor resection (Simpson I or II) was achieved in 19 patients, incomplete resection (Simpson IV) in 11: due to strict tumor adhesion to cerebral arteries in 5 and tumor extension to cavernous sinus in 6 cases. Operative mortality was 6.7%. Visual acuity improved in six among nine patients with impaired vision but in no one among nine patients with blindness. Normal life activity (80–100 KPS) could be carried out by 88% patients at follow-up. Recurrence was observed in two (11.8%) patients after radical removal and progression of residual tumor in two (25%) after subtotal resection.

Conclusions: Complete tumor removal is possible with an acceptable risk of death and severe neurological deficits, except for cases with tumor extension to the cavernous sinus or strict tumor adhesion to cerebral arteries. Visual acuity improvement may be expected in two thirds of patients with impaired vision, but not in cases of blindness. In cases of incomplete tumor removal, use of stereotactic radiosurgery immediately after surgery seems justified.

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1. Introduction

Sphenoid wing meningiomas are traditionally divided into tumors of the outer part (pterional meningiomas), the middle

part, and the inner (medial) part of the wing [1]. Among the latter group, meningiomas with dural attachment at the anterior clinoid process (clinoidal meningiomas) are distinguished [2–4]. Based on anatomical intraoperative observations and observed surgical difficulties, anterior

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clinoidal meningiomas were divided by Al-Mefty in 1990 [5] into three groups depending on the location of dural attachment on the anterior clinoid process, which determines the relationship of the tumor to the arteries and the anterior visual pathways. Group I meningiomas originate on lower surface of the process and when grow, they surround the internal carotid artery on its short length after leaving the cavernous sinus, but prior to entering the arachnoid cistern, with the result that they are directly adhering to the arterial adventitia, without interfacing arachnoidal membrane. With further tumor growth, this direct adhesion to the wall of the internal carotid artery can continue to its bifurcation and can encase middle cerebral artery, pushing the arachnoid away. In this anatomical situation, dissection of the tumor from the vessels is usually impossible. Group II includes meningiomas with dural attachment to the superior or lateral surface of the anterior clinoid process, where the internal carotid artery is already surrounded by the carotid cistern, and thus these tumors have a preserved arachnoid layer separating them from the vessels. Both group I and group II tumors are separated from the optic nerve by an arachnoid layer. Group III meningiomas according to the Al-Mefty classification, with dural attachment at the optic foramen, extend into the optic canal and surround the tip of the anterior clinoid process. An arachnoid layer is preserved between the vessels and the tumor but it may be destroyed by tumor invasion within the optic nerve meninges. These tumors are usually small. Al-Mefty classification of anterior clinoidal meningiomas proved to be extremely useful in relation to the expected intraoperative difficulties, possibility of total removal, and outcome. In group I meningiomas which closely encircle the naked artery, complete tumor removal is often not possible [5-7]. In the past, neurosurgeons were satisfied with subtotal removal of these meningiomas with concerns about the risk of damage to the cerebral arteries. Incomplete removal caused these tumors the most frequently regrowing skull base meningiomas [8]. With advances in surgical techniques treatment outcomes improved and safe and complete tumor removal became possible. Currently, not only preservation, but even improvement of vision may be expected after the surgery [4,6,7,9,10].

The aim of this study was to present our own experience in the treatment of anterior clinoidal meningiomas, including evaluation of factors that may affect early and long-term treatment outcomes.

2. Materials and methods

We performed a retrospective analysis of data obtained in 30 consecutive patients (23 women and 7 men) operated on for the anterior clinoidal meningiomas in our Department of Neurosurgery between 1992 and 2011. The mean patient age was 54 years (range 31-72 years, median 55 years). The mean duration of symptoms was 123 weeks (median 52 weeks) but it ranged widely from 5 days to 20 years. The tumor was right-sided in 16 patients and left-sided in 14 patients. Preoperative contrast-enhanced MRI scans were performed in 24 patients, and the remaining patients, who were treated in the first years of the study period, were operated based on computed tomography. CT bone window imaging was performed in

22 patients, digital subtraction angiography in 27 patients, and CT angiography in 3 patients. No preoperative embolization of the tumor was done [11]. Dimension of tumors, defined by the largest diameter of the tumor, ranged from 13 to 64 mm (mean 37.3 mm, median 40 mm). Meningiomas were categorized according to the Al-Mefty classification [5]. Our goal was complete tumor resection with excision or coagulation of its dural attachment. Fronto-orbito-zygomatic approach with superior orbital fissure opening, optic canal unroofing, and extradural anterior clinoidectomy was used. In some patients, anterior clinoid process was removed partially in extradural step of operation, and its remaining fragment intradurally. Histopathologically, all resected tumors were WHO grade I, including transitional subtype in 12, endothelial in 7, meningothelial in 5, fibroblastic in 3 and psammomatous in 3 cases. The extent of resection was evaluated using Simpson scale [8] based on the intraoperative assessment by the surgeon, the result of early postoperative CT and the result of control MRI performed up to 6 months after the surgery. In case of cranial base meningiomas Simpson I removal is not always possible and reasonable to obtain, and thus removal with coagulation of the dural attachment (Simpson II) may also be assessed as a complete removal. For this reason, Simpson I and Simpson II were both categorized as a complete removal when evaluating the results. If even the smallest portion of the tumor was left on the arteries or in the cavernous sinus, tumor removal was assessed as incomplete - Simpson IV. Outcomes were evaluated at the time of discharge and during long-term follow-up based on the assessment of the neurological status and late follow-up MRI findings. Enlargement of the tumor remnant in a late control MRI in relation to the baseline postoperative MRI was considered as tumor progression. Tumor recurrence was recognized in case when the operating surgeon assessed tumor removal as complete (Simpson I or II) as well as no tumor remnant was seen in the baseline postoperative MRI and then reappearance of a tumor was observed in a late control MRI.

The follow-up data were obtained in 25 of 28 patients (89.3%) discharged from our unit. Duration of follow-up ranged from 13 to 193 months (mean 83 months, median 72 months).

Data were analyzed using the Statistica software, version 10.0 (StatSoft). Analyses included basic descriptive statistics, the Student t-test, and contingency tables with the Pearson chi-square test and the exact Fisher test. $P \leq 0.05$ was considered statistically significant.

3. Results

3.1. Symptoms of the disease

The most common first symptom of the disease was ipsilateral visual impairment (in 17 patients), including impaired visual acuity in 13 patients and visual field defects in 4 patients (Table 1). Duration of symptoms in the 17 patients, whose disease started with visual impairment was longer compared to the remaining patients (mean 178 weeks vs. 50 weeks, $p = ns$). Among them, 11 patients had history of visual disturbances longer than one year, including 3 patients with symptoms present for many years (10, 10, and 20 years, respectively).

Table 1 – The first symptom of the disease.

Presenting symptom	Number of patients
Ipsilateral visual acuity impairment	13
Epileptic seizure	7
Visual field defect	4
Headache	3
Diplopia	3

Table 2 – Symptoms and signs found at the time of admission.

Symptoms and signs at the time of admission	Number of patients
Ipsilateral visual acuity impairment	15
Bilateral visual acuity impairment	3
Visual field defect	14
Epilepsy	6
Headaches	6
Hemiparesis	1
Foster–Kennedy syndrome	2
Oculomotor nerve paresis	4
Abducens nerve paresis	2
Facial paresthesias	1
Speech disturbances	2

Symptoms and signs observed at the time of admission are shown in Table 2. The most common symptom was visual acuity impairment, including ipsilateral in 15 patients and bilateral in 3 patients, and 9 of them were blind on the tumor side. Visual field defects were noted in 14 patients.

3.2. Surgical treatment and postoperative course

There were 6 tumors (20%) in group I, 20 (66.7%) in group II, and 4 (13.3%) in group III according to Al-Mefty classification. The tumors were completely removed with excision of the dural attachment and any abnormal bones (Simpson I) in 10 patients or coagulation of the dural attachment only (Simpson II) in 9 patients. In 11 cases, tumor resection was subtotal (Simpson IV), the reasons being extension to the cavernous sinus in 6 patients with Al-Mefty group II meningiomas and close encasement of the internal carotid artery by the tumor in 5 patients with Al-Mefty group I meningiomas. Extent of resection (Simpson I + II vs. Simpson IV) was affected by the tumor characteristics according to Al-Mefty classification. Significantly nonradical operations were the most frequent in Al-Mefty group I, while in all patients with Al-Mefty group III tumors complete removal was achieved (Table 3) ($p = 0.015$).

Table 3 – Extent of resection in relation to the tumor characteristics according to Al-Mefty classification.

Tumor characteristics according to Al-Mefty classification	Extent of resection by the Simpson scale	
	I + II	IV
Group I (n = 6)	1 (16.7%)	5 (83.3%)
Group II (n = 20)	14 (70%)	6 (30%)
Group III (n = 4)	4 (100%)	0

Two patients died after the surgery, including one patient due to an ischemic stroke within the middle cerebral artery territory and postoperative hematoma in tumor bed, and the other patient due to rapidly progressing cerebral edema.

Among 23 patients with preoperative neurological deficits, worsening of the deficits was seen in 4 patients. New neurological deficits developed after the surgery in 13 patients, including oculomotor nerve paresis or palsy in 6, trochlear nerve paresis in 2, abducens nerve paresis in 1, dysphasia in 3, limb paresis in 4, and visual disturbances in 1.

Transiently impaired consciousness was observed during the postoperative course in four patients, including due to postsurgical intracranial hypotension in three patients and cerebral edema in one patient. Two patients experienced hyponatremia, which was caused by cerebral salt wasting syndrome in one patient and the syndrome of inappropriate antidiuretic hormone secretion (SIADH) in another patient.

3.3. Treatment outcomes – visual disturbances

Postoperatively, visual acuity did not improve in any of the nine patients with preoperative blindness. Among the nine patients with impaired visual acuity, vision improvement immediately after the surgery was seen in four, while worsening was noted in two, including transient blindness in one patient. During long-term follow-up, a significant improvement in visual acuity was observed in six patients, including a return to normal visual acuity in four. In addition, three patients also had decreased visual acuity in the contralateral eye which improved in all cases and returned to normal in one patient. In summary, among nine patients with preoperative vision impairment, visual acuity improved in six, remained unchanged in two and worsened in one patient.

Among the 14 patients with visual field defects, improvement immediately after the surgery was seen in 2 and worsening was also seen in 2. During long-term follow-up, an improvement compared to the preoperative status was noted in six patients, including return to normal visual field in one patient.

In one patient without preoperative visual disturbances, a permanent ipsilateral deterioration of visual acuity with hemianopsia was noted after the surgery. In addition, a new permanent visual field defect was seen in another patient. In the statistical analysis, tumor characteristics according to Al-Mefty classification and preoperative duration of visual acuity impairment were not influenced significantly on postoperative visual acuity improvement or deterioration ($p = ns$).

3.4. Treatment outcomes – focal deficits

Hemiparesis seen preoperatively in one patient worsened after the operation in permanent manner. In further four patients (13.3%), hemiparesis occurred after the surgery and remained permanent in one at follow-up.

Speech disturbances, which were seen preoperatively in two patients, resolved in one patient and became permanently worse in another patient. In further three patients, speech disturbances occurred after the surgery, and were transient in only one.

3.5. Treatment outcomes – cranial nerve disturbances

Oculomotor nerve paresis, which was present preoperatively in four patients, transiently worsened in one patient, resolved in two patients, and remained stable in one patient. New oculomotor nerve paresis developed after the surgery in six patients, but resolved during long-term follow-up in five of them. In one patient, permanent trochlear nerve palsy developed postoperatively, and preexisting abducens nerve paresis transiently worsened to complete paralysis. In another patient, preoperative abducens nerve paresis resolved after the surgery.

3.6. Outcomes at hospital discharge

Patient status at discharge was assessed using the Glasgow Outcome Scale (GOS) [12] – Table 4. Twenty-five patients (83.3%) were discharged in a condition permitting normal or independent life activity. Postoperative deterioration leading to severe disability at discharge was observed in three patients (10%). Severe neurological deficits in these patients resulted from ischemic strokes in the territory of the middle cerebral artery, most likely due to refractory vasospasm following extensive manipulation in two cases and as a result of arterial damage during the operation in one case. Operative mortality was 6.7% (2 patients). Tumor dimension, defined by the largest diameter of the tumor, was not found to have impact on outcome according to GOS ($p = ns$). Worse outcomes were observed in patients with incomplete tumor removal (Simpson IV) as compared to patients with complete removal (Simpson I + II), but the difference was not significant – Table 5.

Statistical analysis showed that the tumor characteristics according to the Al-Mefty classification had an effect on incidence of preoperative neurological deficits deterioration after surgery ($p = 0.0052$) and incidence of new neurological deficits occurrence after surgery ($p = 0.029$). Worse results were observed in Al-Mefty group I tumors.

Table 4 – Patient status at discharge as assessed using the Glasgow Outcome Scale (GOS).

Patient status at discharge (GOS)	Number (%) of patients
GR	15 (50%)
MD	10 (33.3%)
SD	3 (10%)
PVS	0
D	2 (6.7%)

Table 5 – Outcome according to GOS in relation to the extent of resection by Simpson scale.

Extent of resection by the Simpson scale	Outcome according to GOS				
	D	PVS	SD	MD	GR
Simpson I + II	1	0	0	6	12
Simpson IV	1	0	3	4	3

Table 6 – Long-term outcomes as assessed by the Karnofsky Performance Scale (KPS).

KPS score	Number of patients
100	7
90	7
80	8
60	1
40	1
0	1

3.7. Adjuvant treatment

Among the 11 patients who underwent subtotal resection (Simpson IV) one patient died in the postoperative period and 3 patients were in poor condition after surgery (GOS:SD) and were not referred for radiotherapy. Of the remaining seven patients: stereotactic radiotherapy was used in three patients with tumor remnants left in the cavernous sinus, resulting in stable remnant tumor size during long-term follow-up and four patients were not referred for radiotherapy with an idea to follow them up with serial MRI, with a view to reoperation followed by radiotherapy in case of tumor progression. Among these four patients who we decided to observe, the contact with two patients with residual tumors in the cavernous sinus was soon lost and no follow-up data were available.

3.8. Long-term outcomes and recurrences

Long-term follow-up data were available for 25 patients, and their assessment using the Karnofsky Performance Scale [13] is shown in Table 6. Normal life activity could be carried out by 22 of them. Pneumonia was the immediate cause of death of one patient with severe neurological deficits 1 year after the surgery.

Of the two patients with residual tumors and with available follow-up, who were not referred for radiotherapy but decided to be observed, one with tumor remnant adhered to internal carotid artery did not show up for scheduled appointments in Outpatient Clinic and returned many years later, with MRI at that time revealing massive tumor progression at the skull base, which was not eligible to any treatment. In the second patient with a small tumor remnant left in the cavernous sinus, tumor progression was found after more than 5 years and the patient died due to meningitis after reoperation.

In two patients after complete removal of the meningioma (Simpson grade II) who were in a good neurological condition, small asymptomatic tumor recurrences were found at 49 and 82 months, respectively, and stereotactic radiotherapy using the gamma knife was used. Their neurological status at the time of the regrowth and after the applied radiation therapy did not change.

4. Discussion

Anterior clinoidal meningiomas due to their close proximity to the optic nerve present most commonly with progressive visual impairment, usually in the ipsilateral eye [4,5,7,11,14,15]. The

incidence of visual acuity disturbances in reported series ranged from 42% to 62% [2,4,7,11,16] and the incidence of visual field defects ranged from 25% to 54% [4,7,11], in our series these deficits were found in 60% and 47% of patients, respectively. Other symptoms and signs include headaches, epilepsy, limb weakness and ophthalmoplegia, the latter mostly resulting from tumor extension to the cavernous sinus [11]. Symptom duration often spans many years, probably due to the fact that these tumors are histologically benign, i.e., WHO grade I, and thus slow-growing [7,11,15,17]. These lesions are much more frequently seen in women [4,5,7,10,11,15,16,18], with no side preference [4,7].

The frequently used surgical access for anterior clinoidal meningiomas is the fronto-orbito-zygomatic approach with extensive removal of bone structures of the skull base, which offers several advantages. Extensive bone removal at the skull base (orbitozygomatic osteotomy, opening of the superior orbital fissure, optic canal unroofing, and anterior clinoidectomy) shortens the surgical approach route and expands the operative window, exposing the space between the optic nerve and the internal carotid artery, which facilitates tumor removal [7,9,10,19]. This allows extradural partial separation of the dural attachment during the first stage of the operation, thereby reducing bleeding during its later stages [4,5,7,10,11,18–20]. However, this wide opening of the bony structures carries a risk of postoperative cerebrospinal fluid leakage, particularly in cases with an aerated anterior clinoid process [11]. Then, lumbar cerebrospinal fluid drainage from the basal cisterns provides additional brain relaxation, resulting together with wide surgical access in rarer or even unnecessary use of automatic spatulas during later stages of operation.

After incision of the dura, wide opening of the Sylvian fissure improves surgical access and optimizes visualization of the arteries in relation to the tumor [4,5,11]. After debulking, it is possible to begin separating the meningioma from the vascular structures, which are often completely encircled by the tumor. Every artery entering the tumor, until it has been proven unquestionably, that it is only nourishing tumor vessel, must be preserved. Even in the absence of an arachnoidal plane between the meningioma and the arterial wall, it is possible using microsurgical technique to attempt separating the tumor from the vessel. However, this procedure entails a risk of arterial wall injury with intraoperative bleeding or vasospasm induced by manipulation, with resulting cerebral ischemia in both situations [5,9,11,16,21]. In these cases, it seems preferable to leave some tumor along the vessel if it cannot be safely separated [18].

A useful maneuver used by some is to cut the falciform ligament at an early intradural stage, which reduces the risk of optic nerve injury during further stages of the operation [7,10,18,19]. If the tumor penetrates into the optic channel, complete optic sheath opening is made up to the annulus of Zinn. The arachnoid is mostly preserved around the optic nerve, which provides a layer on which it is possible to separate the nerve from the tumor. It is necessary to preserve small vessels reaching to the optic nerve and the optic chiasm from the bottom and providing main blood supply to these structures [5].

In cases of tumor extension to the cavernous sinus, its removal from the sinus is associated with a significant risk of a

new or worsening oculomotor nerve deficit [2,7,11,16,21]. For this reason, some authors consider it appropriate to leave a part of the tumor invading the cavernous sinus in these cases, and then to refer such patients for stereotactic radiotherapy after the operation or follow them up for possible tumor progression, if the event of progression, reoperation or radiosurgery is suggested at that moment [7,11,16]. Avoidance of oculomotor nerve deficits is very important because in the event of diplopia or ptosis, otherwise good visual acuity is no longer useful in case of these complications. On the other hand, it is known that removing the part of the tumor which invades the cavernous sinus reduces the risk of recurrence [2,11,16,22]. The decision to remove tumor extension from the cavernous sinus is made by some authors [9] depending on the presence of neurological deficits resulting from sinus involvement at the time of hospitalization. If such neurological deficits are present, this part of the tumor is removed, and if not, it is left in place.

The Al-Mefty classification of anterior clinoidal meningiomas proved its clinical value in many reports with regard to surgical difficulties, resectability and treatment outcomes [11,21]. Total removal is practically impossible in Al-Mefty group I meningiomas due to the fact that these tumors encase the arteries and are directly attached to the adventitia, having no definable arachnoidal plane between the tumor and the arteries [4,5,11,21]. Separation of a tumor which is directly adjacent to the adventitia carries a risk of causing vasospasm as a result of manipulation, or a risk of direct injury to the perforating arteries during aggressive removal [5,11]. Such complications were also seen in two patients in our study. In contrast, Al-Mefty group II meningiomas, in which the arachnoid layer separating the meningioma from the vessels is preserved and provides a plane to separate the tumor, may be removed completely with little risk of neurological complications [5,11,21]. Similarly, total removal with good treatment outcomes is also possible in group III. Some authors [7,16] suggest to exclude Al-Mefty group III tumors from anterior clinoidal meningiomas and categorize them as foramen opticum meningiomas. A limitation of the Al-Mefty classification is the fact that it does not take into account tumor invasion of the cavernous sinus, which is a second reason, in addition to strict tumor adherence to the arteries, for incomplete removal of these meningiomas [10,16,21].

Some authors [4,6,18] propose to include also tumor size for grading anterior clinoidal meningiomas, pointing that in cases of large tumors encasement of vascular and neural structures by growing tumor beyond immediate peri-clinoidal area becomes important and makes total removal of these tumors more difficult. The division of tumors into two groups with a diameter of more and less than 3 cm seems to be useful for predicting surgical outcome and complications rate [6,18]. Indirectly, these results indicate that young and middle-aged patients with incidentally detected anterior clinoidal meningiomas should undergo immediate surgery at the time of tumor detection. The size of operated meningiomas in our cohort was rather large and did not have an effect on the outcomes.

Currently, with use of microsurgical techniques, deterioration of visual acuity is usually not reported after the surgery,

and even visual acuity and visual field improvement are observed in some cases [2,4,7,9-11,14,16,18]. However, when the optic nerve is completely surrounded by the meningioma, worse outcomes regarding the change in visual acuity are observed after the operation [8,11]. It is thought, that in these cases is most likely not only compression exerted on the optic nerve by tumor, but also nerve ischemia occurs and intraoperative manipulation may lead to critical ischemia of the optic nerve, resulting in vision deterioration after the surgery despite nerve decompression [4,11,21]. In patients with ipsilateral loss of vision, no improvement in visual acuity is usually seen [5,16,18]. We also did not observe any vision improvement after the surgery in our patients with preoperative blindness. In contrast to other authors [17,18], we did not find an effect of the symptom duration on the likelihood of vision improvement after the surgery. It is worth emphasizing the fact that worsening of visual acuity occurred in only one of the 11 patients with preoperative normal visual acuity, and except for that patient, visual field deterioration after the surgery was seen only in one other patient with normal visual field before the surgery, which is consistent with other reports [2,7,10,11,16].

With advances in imaging techniques and skull base surgery, it is now increasingly possible to remove these tumors completely with an acceptable risk of complications. The mortality rate among patients with clinoidal meningiomas remains high, ranging from 0% to 15.2% [4,5,7,9-11,15-18,21], and the proportion of patients with severe neurological deficits after the surgery, preventing them to live independently, has been reported to range between 4.8% and 20% [9,11,18]. In our study, these figures were 6.7% and 10%, respectively.

Advances in last years in expanded endoscopic endonasal surgery make possible access through this route to many pathologies of the skull base including also meningiomas. This technique has some advantages like an early access to tumor blood supply resulting in reduction of intraoperative blood loss and like an elimination of the need for brain retraction. Some disadvantages also exist such as a risk of damage to olfaction and a risk of postoperative cerebrospinal fluid leak, the incidence of which in the literature reaches 20% and varies by tumor location [23,24]. It is worth to emphasize that leaks can usually be resolved without craniotomy [25]. Vascular encasement, tumor consistency and large size of tumors are also limitations of procedure [23,24]. There is a paucity of literature data regarding anterior clinoidal meningiomas removal using this approach [26], unlike the literature on removal of e.g. tuberculum sellae, planum sphenoidale or olfactory meningiomas [25,27-29]. The use of endoscopic endonasal approach for anterior clinoidal meningiomas has been controversial due to dural attachment of these tumors laterally from the midline [29]. The endoscopic technique may eventually find an application in the removal of small-sized tumors without internal carotid artery encasement [26].

The goal of surgical treatment of these tumors is to remove them completely without causing new permanent neurological deficits. The treatment approach to patients with some residual tumor tissue left in the cavernous sinus or adhering closely to the arteries is still a matter of debate. Some authors recommend the use of stereotactic radiation therapy after the

surgery [4,5,17] while others [9,11,14,18,21] suggest follow-up with serial MRI studies and reoperation or stereotactic irradiation in case of tumor progression. Aziz et al. [2] suggested that patients with a residual tumor be referred for stereotactic radiotherapy in cases of medium to high values of the Ki-67 proliferation index, while those with low Ki-67 index values be followed up with serial MRI examinations, with reoperation or radiosurgery at the time of tumor progression. Nakamura et al. [16] in cases when several consecutive preoperative MRI examinations were available referred patients with a remnant tumor in the cavernous sinus for gamma-knife radiosurgery depending on the observed rate of tumor growth before the surgery. If the tumor was growing rapidly, patients were referred for radiosurgery. If the tumor was growing slowly (or multiple preoperative MRI examinations were not available), patients were closely followed up by repeated MRI examinations and in case of tumor progression they were most often reoperated, less frequently referred for radiotherapy. Following complete tumor removal, no more than about 10% recurrence rate during several years of follow-up may be expected according to most reports [4,11,16,17]. The situation is quite different in cases of incomplete tumor removal, with tumor regrowth rate up to 50% [4,11,16-18,21]. In our study, we observed a recurrence in 2 (11.8%) of the 17 patients after radical tumor removal and progression of the residual tumor in 2 (25%) of the 8 patients after subtotal resection.

Postoperative radiotherapy effectively prevents further growth of the residual tumor in many cases [4] but its use causes some problems in case of regrowth noted during further follow-up [11]. In such cases, postradiation changes cause that reoperation is associated with a high failure rate of the removal of a significant tumor mass, and is associated with a much higher complication rate. Mathiesen et al. [17] in a very long-term follow-up study found that radiation therapy of the residual tumor improved survival at 10 years, but a difference in survival was no longer observed at 20 years.

5. Conclusions

1. Complete removal of anterior clinoidal meningiomas is possible in most of the patients with an acceptable risk of death and severe neurological deficits, however in cases with tumor extension to the cavernous sinus or strict tumor adhesion to cerebral arteries it is reasonable to leave this part of the tumor unresected.
2. Despite close tumor proximity to the optic nerve and optic chiasm, there is essentially small risk of visual acuity deterioration after the surgery, and visual acuity improvement may even be expected in two thirds of patients with impaired vision, but not in cases of blindness.
3. In cases of incomplete tumor removal, the use of stereotactic radiosurgery immediately after the surgery seems justified.

Conflict of interest

Authors declare no conflict of interest.

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Ethics

The work described in this article has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans; Uniform Requirements for manuscripts submitted to Biomedical journals.

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