ORIGINAL PAPER/*ARTYKUŁ ORYGINALNY*

# Direct and remote outcome after treatment of tumours involving the subtemporal fossa and related structures with the extended subtemporal approach

## *Bezpośrednie i odległe wyniki leczenia guzów dołu podskroniowego i jego otoczenia z wykorzystaniem dostępu podskroniowego rozszerzonego*

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## Abstract

**Background and purpose:** The aim of the study was to present our results of the surgical treatment of subtemporal fossa tumours and surrounding regions using the extended subtemporal approach.
**Material and methods:** Twenty-five patients (10 women, 15 men) with subtemporal fossa tumours were included in the study. The neurological and performance status of the patients were assessed before and after surgery as well as at the conclusion of treatment. The approximate volume of the operated tumour, its relation to large blood vessels and cranial nerves, as well as consistency and vascularisation were assessed.
**Results:** The symptom duration ranged from 2 to 80 months (mean: 14 months). In 44% of patients, headache was the predominant symptom. Less frequent symptoms were: paralysis of the abducent nerve and disturbances of the trigeminal nerve. Approximate volume of the tumours ranged from 13 to 169 $cm^3$ (mean: 66 $cm^3$). The most frequent histological diagnosis was meningioma (16%), followed by angiofibroma, neurinoma and adenocystic carcinoma (12%). Total or subtotal resection was achieved in 80% of patients.
**Conclusions:** The extended subtemporal approach allows for the removal of tumours of the subtemporal fossa and surro-

## Streszczenie

**Wstęp i cel pracy:** Celem niniejszej pracy jest przedstawienie własnych wyników leczenia operacyjnego guzów dołu podskroniowego i jego otoczenia z wykorzystaniem dostępu podskroniowego rozszerzonego.
**Materiał i metody:** Analizie poddano 25 przypadków guzów dołu podskroniowego, wśród których było 10 kobiet i 15 mężczyzn. Ocenie podlegał stan neurologiczny chorych przed rozpoczęciem leczenia, po operacji i po zakończeniu leczenia. Określano przybliżoną objętość operowanych guzów, ich stosunek do dużych naczyń i nerwów czaszkowych oraz konsystencję i stopień unaczynienia.
**Wyniki:** Długość wywiadu wahała się od 2 do 80 miesięcy i wynosiła średnio 14 miesięcy. W 44% przypadków wiodącym objawem był ból głowy. Rzadziej występowały niedowład lub porażenie nerwu odwodzącego oraz zaburzenia ze strony nerwu trójdzielnego. Przybliżona objętość usuniętych guzów wahała się od 13 do 169 $cm^3$ i wynosiła średnio 66 $cm^3$. Wśród usuniętych guzów najczęściej powtarzał się oponiak (16%). Rzadziej, bo w 12%, występowały naczyniakowłókniak, nerwiak i rak gruczołowo-torbielowaty. W 80% przypadków przeprowadzone resekcje były doszczętne lub z niewielkimi pozostałościami guzów.

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unding regions. This approach also allows one to remove tumours expanding in the regions surrounding the subtemporal fossa only. In such cases the subtemporal fossa constitutes the way of the surgical approach.

**Key words:** subtemporal fossa, meningioma, angiofibroma, trigeminal neuroma, microsurgery.

**Wnioski:** Dostęp podskroniowy rozszerzony pozwala na usuwanie guzów dołu podskroniowego i graniczących z nim obszarów anatomicznych. Dostęp ten pozwala również na usuwanie guzów rozrastających się tylko w obszarach graniczących z dołem podskroniowym. W tych wypadkach dół podskroniowy stanowi drogę dostępu chirurgicznego.

**Słowa kluczowe:** dół podskroniowy, oponiak, naczyniakowłókniak, nerwiak nerwu trójdzielnego, mikrochirurgia.

## Introduction

The primary idea of the authors from the Clinical Department of Neurosurgery at Sosnowiec that inspired the following paper was to introduce an extended subtemporal approach as a surgical modality in the treatment of tumours restricted to the subtemporal fossa as well as those that extend into the vicinity and involve the cranial cavity, orbit, maxillary and/or sphenoid sinus. The most usual types of tumours in this region include meningiomas, chordomas and neurofibromas. Angiofibromas are a separate group of tumours that might be approached via the subtemporal approach extended toward the pterygopalatine fossa and posterior nostrils. Importantly, co-operation with the Department of Oncological and Reconstructive Surgery of the Gliwice Branch of the Maria Skłodowska-Curie Memorial Cancer Centre and Institute of Oncology allowed us to extend the indications for this approach to malignant tumours of epithelial and adenoid origins that involve the maxillary sinus, nasal cavity, pterygopalatine fossa, posterior nostrils, orbit and subtemporal fossa itself.

The aim of this paper is to present our results of the surgical treatment of tumours of the subtemporal fossa and surrounding regions using the extended subtemporal approach.

## Material and methods

A retrospective analysis of 25 (10 women, 15 men, aged 7 to 73 years) cases of tumours that involved the subtemporal fossa and its vicinity, treated in the Clinical Department of Neurosurgery in Sosnowiec and the Department of Oncological and Reconstructive Surgery of the Gliwice Branch of the Maria Skłodowska-Curie Memorial Cancer Centre and Institute of Oncology between 1998 and 2008 was performed. Each tumour occupied several anatomical regions. In 88% of cases they involved the subtemporal fossa. The middle cranial fossa, temporal fossa and pterygopalatine fossa were involved in 40% of cases. Penetration of the cavernous and maxillary sinuses along with the posterior nostrils was present in 32%, while the sphenoid sinus, orbit, cribriform plate and nasal cavity were infiltrated in 28% of cases. Regions infrequently involved include the posterior fossa, clivus, interpeduncular fossa, parapharyngeal space and palate.

Neurological status of the patients at the beginning of the treatment, immediately after surgery and no sooner than 6 months after surgery (Tables 1 and 2) along with changes of everyday performance assessed with Karnofsky scale (Table 3) were analysed. The volumes of the tumours were approximated with Di Chiro and Nelson's formula for a rotational ellipsoid ($volume = \Pi/6\ (x \times y \times z)$), based on magnetic resonance imaging (MRI). The extent of resection was assessed based on pre- and postoperative MRI examinations; in meningioma cases Simpson's scale was used. The relationship of tumours to large vessels, cranial nerves, their consistency and vascularisation were analysed as well.

Average times of catamnesis, postoperative follow-up and tumour volumes were presented as median with standard error of mean (SEM).

## Results

The time of catamnesis for all the patients varied from 2 to 80 months and averaged 14 months (median = 8 months, SEM = 4.16). The most common clinical sign for a tumour was either diffuse or localized headache. In 4 cases, a tumour in the integuments was noticed. Neurological examination usually revealed disturbances of II, III, IV or VI cranial nerves and, in the cases with nasal cavity penetration, nasal discharge. All the signs and symptoms are summarized in Table 1.

Approximated volume of the tumours varied from 13 to 169 $cm^3$ and averaged 66 $cm^3$ (median = 46.9 $cm^3$,

**Table 1.** Changes in neurological abnormalities that occurred before surgical treatment with the extended subtemporal approach (25 cases)

| Neurological abnormality | Examination on admission | Examination on discharge | Follow-up examination |
|---|---|---|---|
| Unilateral blindness | 2 | 2 | 2 |
| Exophthalmos | 5 | 1 | 0 |
| III nerve palsy or paresis | 4 | 4 | 3 |
| VI nerve palsy or paresis | 3 | 3 | 3 |
| Decreased sensation in distribution of ophthalmic nerve | 2 | 2 | 1 |
| Decreased sensation in distribution of maxillary nerve | 3 | 3 | 2 |
| Decreased sensation in distribution of mandibular nerve | 8 | 8 | 8 |
| Peripheral VII nerve palsy or paresis | 2 | 2 | 2 |
| IX nerve palsy or paresis | 2 | 2 | 2 |
| Unilateral hypoacusis | 2 | 2 | 0 |
| Hemiparesis | 3 | 2 | 2 |
| Headache | 11 | 0 | 0 |

**Table 2.** Changes in the neurological status which occurred after surgical treatment with the extended subtemporal approach (25 cases)

| Neurological abnormality | Examination on admission | Examination on discharge | Follow-up examination |
|---|---|---|---|
| III nerve palsy or paresis | 5 | 5 | 1 |
| IV nerve palsy or paresis | 5 | 5 | 1 |
| VI nerve palsy or paresis | 1 | 1 | 0 |
| Decreased sensation in distribution of ophthalmic nerve | 5 | 5 | 2 |
| Decreased sensation in distribution of maxillary nerve | 8 | 8 | 3 |
| Decreased sensation in distribution of mandibular nerve | 5 | 5 | 1 |
| Causalgia after V nerve transsection | 1 | 1 | 1 |
| VII nerve palsy or paresis | 1 | 1 | 0 |
| Decreased lacrimation | 1 | 1 | 1 |
| Hemiparesis | 1 | 1 | 0 |
| Psycho-organic syndrome | 1 | 1 | 0 |

SEM = 11.81). Histopathologically, tumours were heterogeneous; however, most of them were benign. Four diagnoses were seen repeatedly: meningiomas, angiofibromas, neurinomas and cystic adenocarcinomas. Table 4 comprises a complete description of histopathological features of tumours in our cohort. Tumours resected via the extended subtemporal approach in 88% of cases were adjacent, adherent or surrounded maxillary and mandibular nerves. Penetration of cavernous sinuses' walls or its interiors (32%) resulted in contact, adhesions or encasement of the oculomotor and trochlear nerves and, in selected cases, the abducent nerve as well. In 2 cases tumours that filled the cavernous sinus were adherent to or encased the internal carotid artery (confirmed by postoperative histopathological examination). Tumours adjacent, potentially adherent or encasing the maxillary artery were seen in 72% of cases.

The vast majority of the tumours described were solid in consistency. Forty-eight percent of tumours were scantily vascular and required infrequent haemostasis during resection, while 40% of them were highly vascular, which resulted in frequent deferrals of resection in order to perform haemostasis. Angiofibroma surgery

**Table 3.** Assessment of functional capacity of patients treated with extended subtemporal approach according to Karnofsky performance scale

| Patient | Examination on admission | Examination on discharge | Follow-up examination |
|---|---|---|---|
| Patient No. 1, D.W. | 80 | 80 | 90 |
| Patient No. 2, W.S. | 80 | 90 | 70 |
| Patient No. 3, A.W. | 80 | 70 | 90 |
| Patient No. 4, J.B. | 70 | 70 | 40 |
| Patient No. 5, A.S. | 80 | 70 | 80 |
| Patient No. 6, E.C. | 90 | 70 | 90 |
| Patient No. 7, W.S. | 90 | 90 | 90 |
| Patient No. 8, D.B. | 90 | 90 | 90 |
| Patient No. 9, A.K. | 90 | 80 | 90 |
| Patient No. 10, Z.M. | 90 | 80 | 80 |
| Patient No. 11, P.T. | 90 | 90 | 90 |
| Patient No. 12, R.F. | 90 | 80 | 90 |
| Patient No. 13, W.W. | 70 | 60 | 80 |
| Patient No. 14, K.I. | 80 | 70 | 80 |
| Patient No. 15, M.O. | 80 | 70 | 80 |
| Patient No. 16, K.N. | 90 | 80 | 80 |
| Patient No. 17, B.J. | 80 | 80 | 80 |
| Patient No. 18, K.O. | 90 | 80 | 80 |
| Patient No. 19, M.N. | 90 | 90 | 90 |
| Patient No. 20, R.F. | 90 | 80 | 90 |
| Patient No. 21, F.P. | 70 | 60 | 70 |
| Patient No. 22, J.B. | 80 | 80 | 80 |
| Patient No. 23, D.B. | 80 | 70 | 80 |
| Patient No. 24, P.L. | 90 | 80 | 80 |
| Patient No. 25, A.B. | 80 | 80 | 80 |

was preceded by elective embolization. In 6 cases transsections of 2 branches of the trigeminal nerve were necessary. Three cases where the abducent nerve was encased in the tumour within Dorello's canal also required transsection of the nerve.

Eighty percent of resections were complete. No progression of tumour remnants was observed. None of the patients died in the early postoperative period. Three patients succumbed in the late postoperative period due to progression of the malignancies. In one case, a patient died 8 months after surgery with the symptoms of multiple bony metastases from prostate adenocarcinoma. Neurosurgical resection of a metastatic tumour entailed en-bloc removal with healthy margins that was confirmed by histopathological examination. The patient did not qualify for surgical treatment of the primary disease and received only palliative hormone therapy. The second case, a 7-year-old child, underwent surgery for primitive neuroectodermal tumour. In this case, healthy margins were preserved as well; en-bloc resection was not feasible, however. Despite the intense adjuvant radio- and chemotherapy, a massive recurrence killed the patient 7 months after surgery. The third fatality involved a patient who had a cystic adenocarcinoma of the pterygopalatine fossa removed. A local relapse of the tumour was seen 16 months after surgery. The patient succumbed due to generalized malignancy 2 years after surgery.

**Table 4.** Histopathological characteristics of tumours resected with the extended subtemporal approach (25 cases)

| Histopathological diagnosis | Number of cases |
|---|---|
| Meningioma | 4 |
| Angiofibroma | 3 |
| Neurinoma | 3 |
| Cystic adenocarcinoma | 3 |
| Neurofibroma | 2 |
| Squamous cell carcinoma | 2 |
| Chordoma | 2 |
| Haemangiopericytoma | 1 |
| Histiocytoma | 1 |
| Angiolipoma | 1 |
| Teratoma | 1 |
| Primitive neuroectodermal tumour | 1 |
| Prostate cancer, metastatic tumour | 1 |

Adjuvant radio- or chemotherapy or a combination of both was administered in 40% of cases. Importantly, in 16% of cases the post-surgical tissue deficit after tumour removal, in some of the cases exacerbated by pterygoid muscle amputation during the surgical approach, was large enough to require reconstructive surgery with a free tissue flap. A flap was harvested from the rectus abdominis with a vascular peduncle on the lower epigastric artery and vein. Vessels were anastomosed to the facial artery and internal jugular vein, respectively.

The follow-up period ranged from 7 to 116 months and averaged 38.1 months (median = 37 months, SEM = 2.92).

The deficits of function of cranial nerves present before treatment remained unchanged at the time of discharge from the hospital. During the follow-up, resolu-

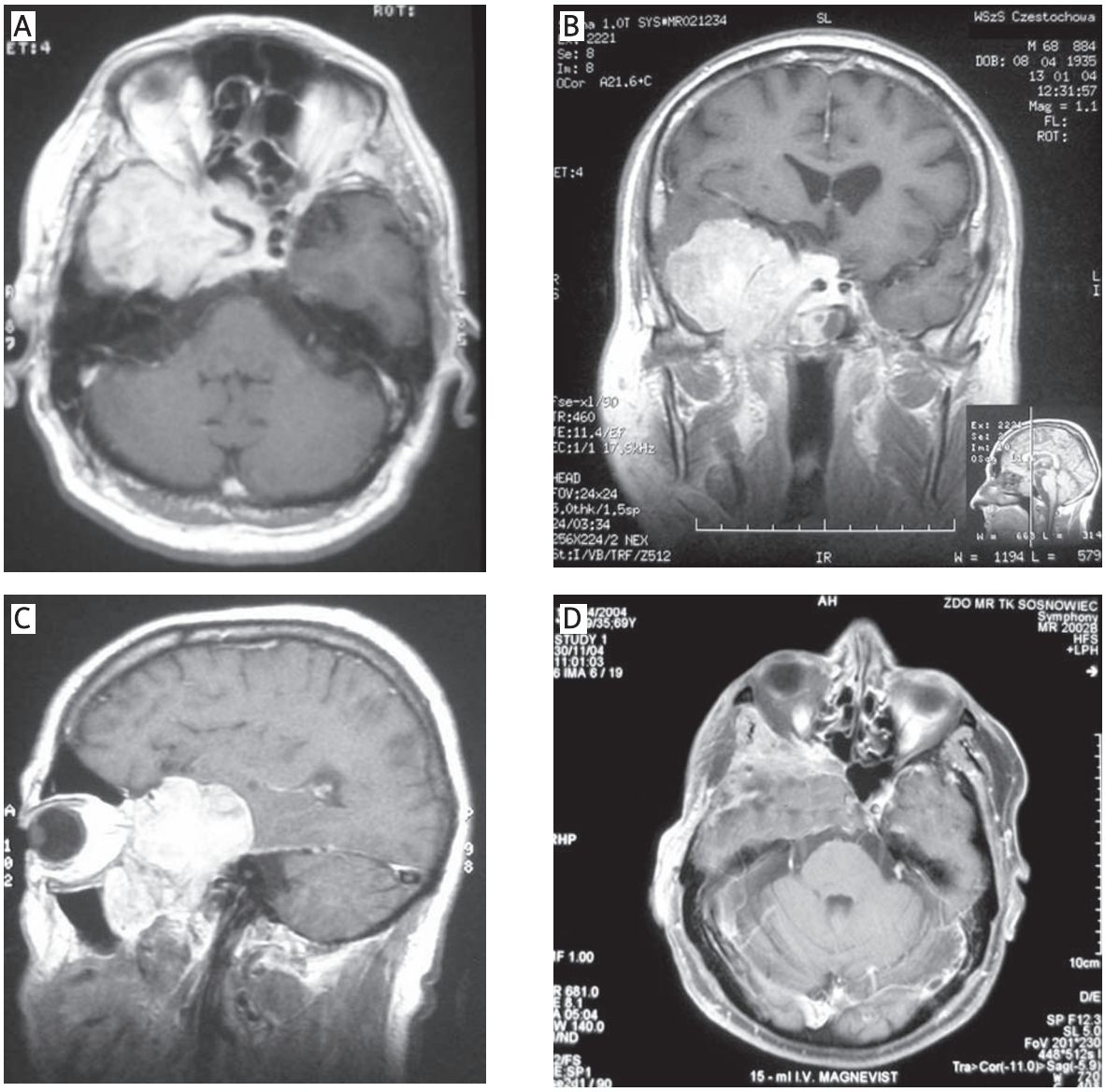


**Fig. 1.** Meningioma of the border of the anterior and middle cranial base and middle cranial fossa on the right (patient no. 14, K.I., age 69 years). The patient presented with III nerve palsy and sensory deficits within innervation areas of $V_2$ and $V_3$ branches of the trigeminal nerve. Tumour removal was macroscopically total. A temporal muscle was transposed into the tumour cavity. After the surgery, III, IV and VI nerve paresis that progressed to permanent palsy within 5 months was present. Follow-up period – 59 months

A) tumour seen in the axial plane on preoperative MRI, B) tumour seen in the coronal plane on preoperative MRI, C) tumour seen in the sagittal plane on preoperative MRI, D) status after removal of the tumour seen in the axial plane on postoperative MRI, E) status after removal of the tumour seen in the coronal plane on postoperative MRI

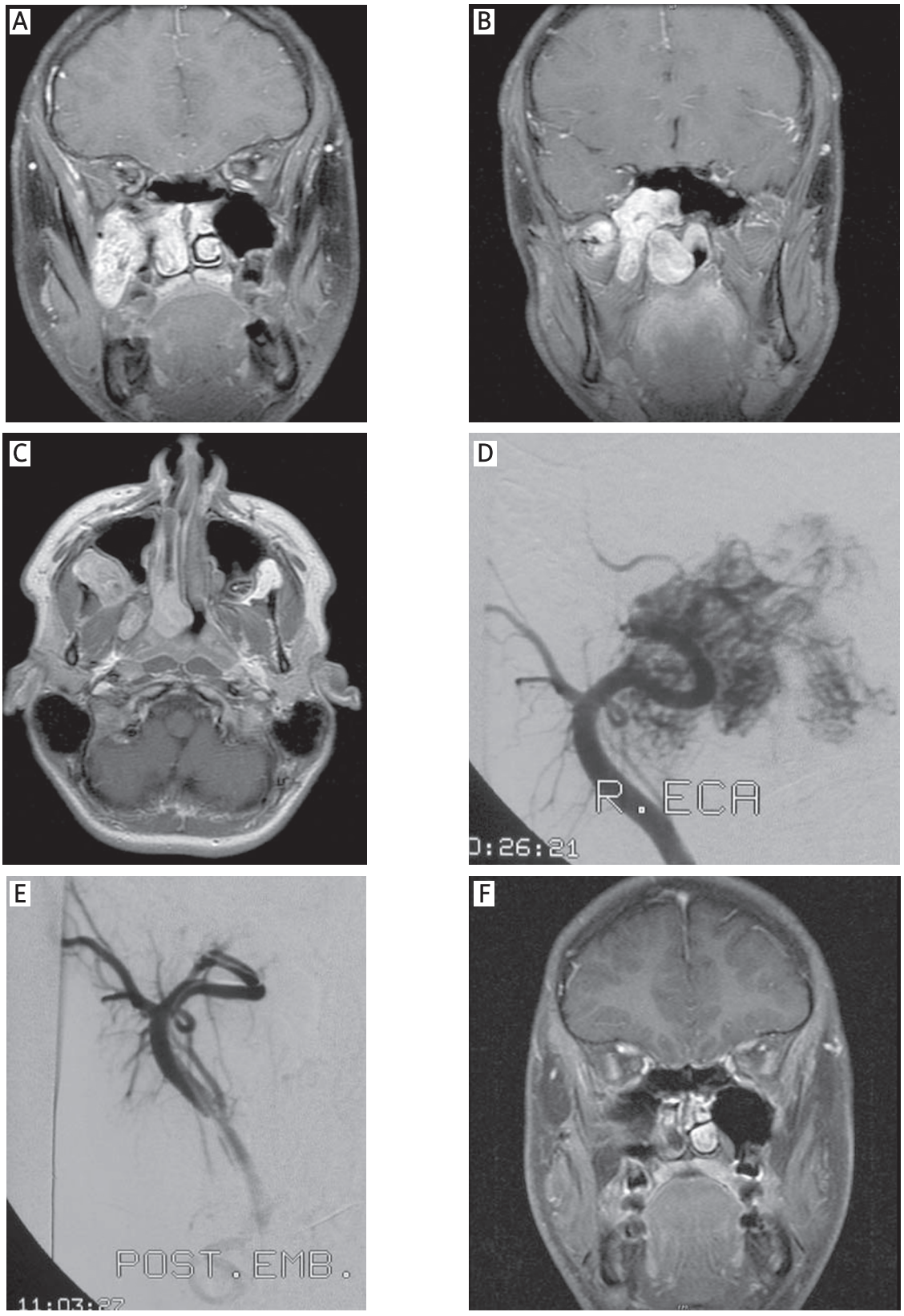


**Fig. 2.** (continued on the next page)

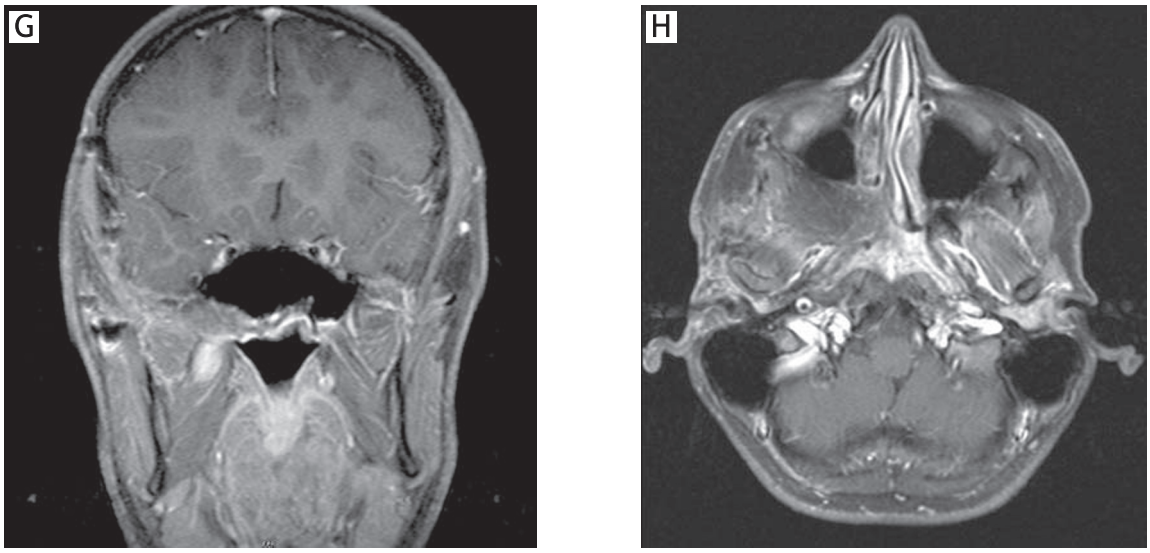


**Fig. 2.** Angiofibroma of the border of the anterior and middle cranial base on the right (patient no. 8, D.B., age 17 years). Over 5 months prior to surgery a nasal blockage developed. Four episodes of massive epistaxis also occurred. Preoperative embolization of the tumour was performed owing to extensive, pathological vascularisation from the right external carotid artery. The tumour was removed completely and the remaining cavity in the subtemporal fossa was packed with a free flap harvested from the rectus abdominis. Follow-up period – 72 months

A) tumour seen in coronal plane I on preoperative MRI, B) tumour seen in coronal plane II on preoperative MRI, C) tumour seen in the axial plane on preoperative MRI, D) right external carotid artery angiography before embolization, E) right external carotid artery angiography after embolization, F) status after removal of the tumour seen in coronal plane I on postoperative MRI, G) status after removal of the tumour seen in coronal plane II on postoperative MRI, H) status after removal of the tumour seen in the axial plane on postoperative MRI

tion of sensory deficits within the innervation areas of ophthalmic and maxillary nerves was seen (Table 1). Immediately after surgery, regression of signs and symptoms such as exophthalmos, headaches, tumour within head integuments, nasal blockage and pathological nasal discharge was noticed. Imminent to surgery, sensory deficits within innervation areas of trigeminal nerve branches were observed that regressed in some of the patients during the follow-up (Table 2). Pareses or paralyses of cranial nerves responsible for ocular motility were present as well. Similarly, they resolved in some of the cases during the follow-up. In one of the patients whose trigeminal nerve was transected during the procedure, treatment-resistant trigeminal causalgia occurred after surgery.

Comparison of the functional capacities of the patients on admission and during the follow-up, as measured with the Karnofsky performance scale, revealed improvement in 16%, unchanged condition in 60% and deterioration in 24% of patients.

## Discussion

Malignant and benign tumours are equally frequent in the subtemporal fossa and its vicinity [1-4]. In the group of cases presented in this paper, the majority of tumours were benign, although the small number of patients does not allow us to draw any long-range conclusions.

Shaheen [5] points out that subtemporal fossa tumours, as long as they are confined to its margins, are poorly accessible for examination. Tumour spread outside the subtemporal fossa throughout natural anatomical pathways goes in hand with the appearance of clinical signs that suggest its presence. Tumour within the integuments, usually in the temporal region above the zygomatic arch, might be present. Deformation of the lateral wall of the pharynx or exophthalmos may also occur. Rarely, physical examination reveals tumour penetration toward the oral cavity. It is feasible, however, to palpate it between the arm of the mandible and maxilla. Despite the aforementioned observations it is difficult to depict a consistent clinical representation of this group of tumours. Headache, a highly unspecific symptom, was the most common one in the collected data set. Sensory deficits within the innervation area of the mandibular nerve, seldom within the innervation areas of the other two branches of the trigeminal nerve, present in 32% of cases, were quite a common sign. One can suggest that coincidence of physical signs described

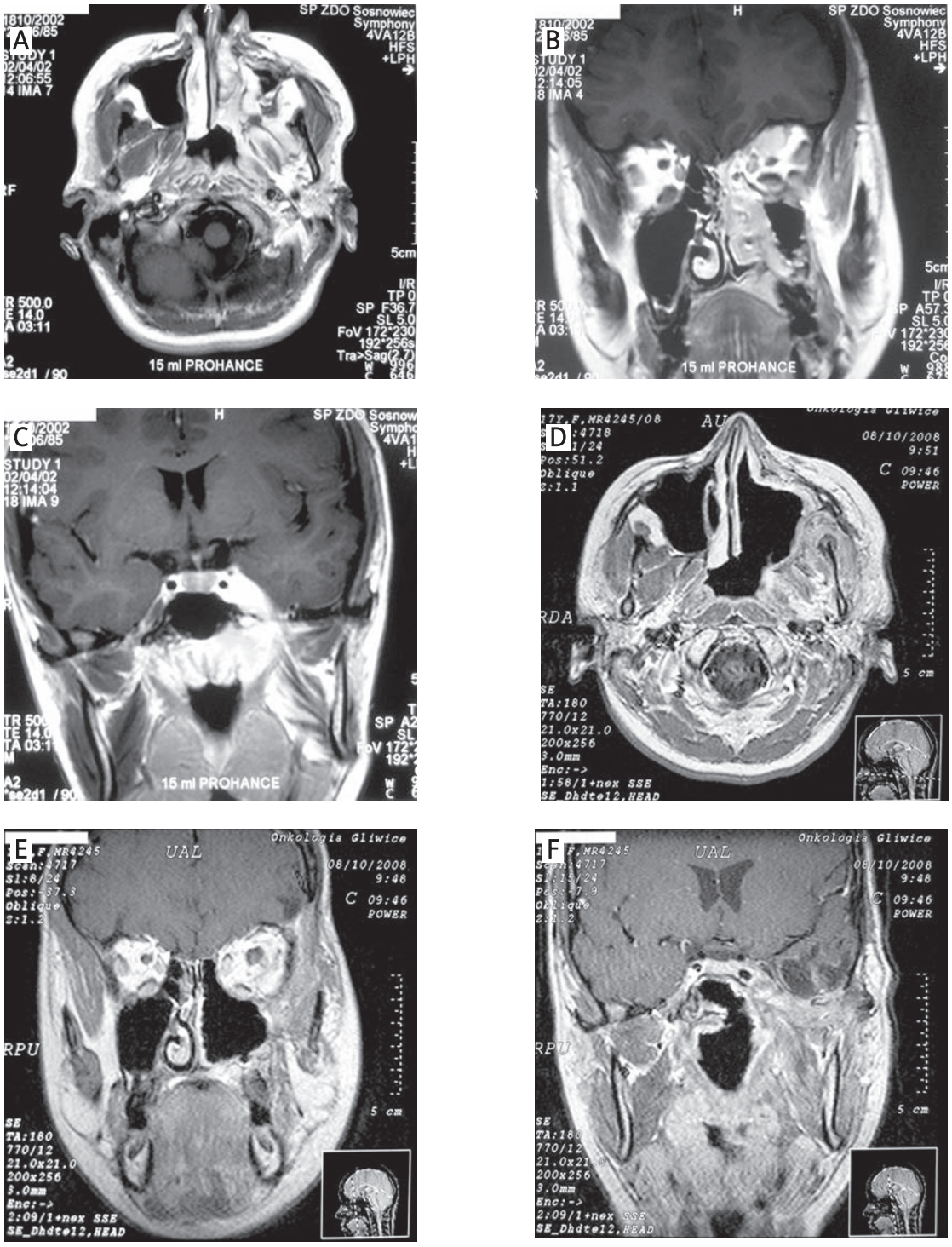


**Fig. 3.** Cystic adenocarcinoma of the border of the anterior and middle cranial base on the left (patient no. 5, A.S., age 16 years). The patient presented with exophthalmos and III nerve paresis on the left. The patient's parents refused to agree to orbit exenteration as part of the surgical treatment plan. The tumour was removed without healthy tissue margins within the cavernous sinus and the orbit. The patient underwent radiotherapy that resulted in blindness of the left eye. Regular check-ups have not revealed any signs of recurrence. Follow-up period – 81 months

A) tumour seen in the axial plane on preoperative MRI, B) tumour seen in coronal plane I on preoperative MRI, C) tumour seen in coronal plane II on preoperative MRI, D) status after removal of the tumour seen in the axial plane on postoperative MRI, E) status after removal of the tumour seen in coronal plane I on postoperative MRI, F) status after removal of the tumour seen in coronal plane II on postoperative MRI

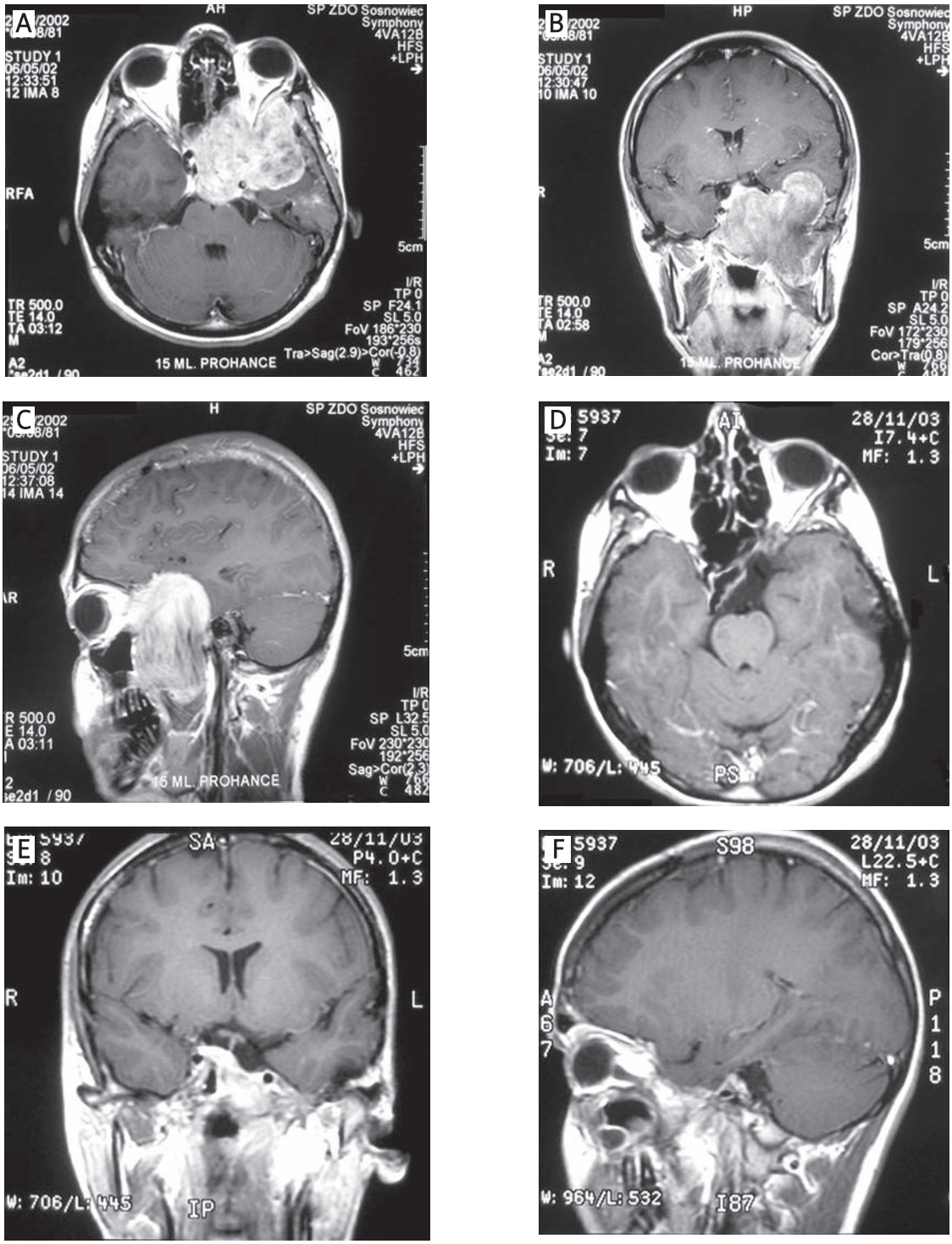


**Fig. 4.** Neurofibroma of the border of the anterior and middle cranial base on the left (patient no. 6, E.C., age 21 years). The patient over an 11-month period developed exophthalmos, hypoacusis and peripheral VII nerve paresis on the left. The tumour was removed totally. Subsequent to surgery the patient developed III, IV and VI nerve palsy on the left and deepened VII nerve paresis due to greater petrosal nerve encasement within the tumour. During the follow-up all of the preoperative and postoperative deficits except for VI nerve palsy subsided. The left eye bulb was repositioned. Follow-up period – 82 months

A) tumour seen in the axial plane on preoperative MRI, B) tumour seen in the coronal plane on preoperative MRI, C) tumour seen in the sagittal plane on preoperative MRI, D) status after removal of the tumour seen in the axial plane on postoperative MRI, E) status after removal of the tumour seen in the coronal plane on postoperative MRI, F) status after removal of the tumour seen in the sagittal plane on postoperative MRI

by Shaheen [5] along with the above-mentioned sensory disturbances might be of diagnostic value.

The most common benign tumours in our group were meningiomas. Due to their anatomical background these tumours secondarily invade the subtemporal fossa [6]. Continual information of extensive hyperostoses that accompany subtemporal fossa meningiomas [2,6] has been confirmed in a sole case in our group. Conversely, in agreement with previous reports [2,6] all of the meningiomas in this region presented in our paper tended to invade muscles, nerves and mucosa, in some cases even the periorbit.

A distinctive benign tumour usually located in the subtemporal fossa and its vicinity is a juvenile angiofibroma [1-4,7,8]. We found three cases in our group. This tumour is typical for young males [2]. It expands from the posterior part of the roof of the nasal cavity. It can invade the subtemporal fossa via the pterygopalatine fossa. Fisch [7] distinguishes four groups of juvenile angiofibromas: (1) limited to the nasopharynx and nasal cavity, (2) involving the pterygopalatine fossa, sphenoid and maxillary sinuses and cribriform plate, (3) involving the subtemporal fossa, orbit and parasellar region, and (4) those penetrating the cavernous sinus, optic chiasm region and pituitary gland. A characteristic feature for this type of tumour is a very rich vasculature. Radical surgical resection is believed to be the best therapeutic modality [2]. Reconciliation of these two facts might be difficult, however. Embolization prior to surgery is a treatment of choice in those highly vascular tumours [9].

Neurinomas were just as frequent as angiofibromas among benign tumours described in this paper. In all those cases the neurinoma originated from the trigeminal nerve, but it expanded into the subtemporal fossa in two cases only. Typical locations for trigeminal nerve neurinomas include the middle cranial fossa, posterior fossa and, in the case of dumb-bell tumours, the borderline between the two [10,11]. Subtemporal fossa location results from neurinoma expansion along the mandibular nerve [12,13]. The extended subtemporal approach is then an obvious choice for tumours in this location. The subtemporal fossa approach in a case of trigeminal nerve neurinoma with middle fossa location described by Goel *et al*. [14] is imposed by the drive to avoid temporal lobe pressure during the resection of the greater wing of the sphenoid, as in one of the cases treated by the authors.

Rules similar to those pertinent for malignant tumours in other locations apply to surgical removal of malignant tumours of the subtemporal fossa and its vicinity. This means that tumours should be resected en-bloc with healthy tissue margins. It is worth mentioning, however, that the subtemporal fossa, unlike any other skull base regions, gives the opportunity to fulfil these requirements. The chances are the highest in cases where the tumour is restricted to the subtemporal fossa and decrease when the tumour penetrates into the surrounding structures. Friedman *et al*. [15] advise that en-bloc resection margins of tissue block should encompass the zygomatic arch and arm of the mandible, posterior wall of the maxillary sinus, styloid process, greater wing of the sphenoid and medial pterygoid plate with the hamulus.

A number of reports describe survival rates of two years or longer after radical resections with subsequent radiotherapy of malignant tumours of the subtemporal fossa and its vicinity [7,2,16-18]. Our results corroborate the reports of others. Survival rates are clearly influenced by the extent of neoplastic infiltration; they are also affected by the sequence of surgery, i.e. whether it is performed on primary or secondary, recurrent tumour [7]. Our cohort included ten malignant tumours. In three cases patients succumbed to progression of the primary disease. While in the case of a patient with metastatic prostate adenocarcinoma progression of the disease was related to an active primary site, in the case of a patient with a primitive neuroectodermal tumour, death was a consequence of skull base tumour recurrence. In this patient a gross total resection with healthy tissue margins was accomplished, not en-bloc though. Whether or not this fact could be a reason for the recurrence is still a matter of debate. For the patient with cystic adenocarcinoma who died two years after surgery, the resection was completed in en-bloc fashion and intraoperative histopathological assessment of the cavity walls revealed no tumour cells. It is possible that a recurrence that was considered local was in fact an extension of the tumour along the nerve stems that was independent of the resection technique.

Biopsy plays an important role in the treatment protocol for tumours of the subtemporal fossa and its vicinity. Its results might influence the relationship between adjuvant radio- and chemotherapy and surgical treatment or determine the surgical strategy. The biopsy, either needle or open, might be performed through the temporal fossa, oral cavity or the pharynx [5]. Diagnostics aimed at the status of regional lymph nodes are also of great value for malignant tumours of this region [18].

## Conclusions

1. The extended subtemporal approach enables removal of tumours of the subtemporal fossa and adjacent anatomical regions that include the middle cranial fossa, temporal fossa, pterygopalatine fossa, maxillary sinus, sphenoid sinus, cavernous sinus, orbit, posterior nostrils, nasal cavity, cribriform plate, parapharyngeal space, retromandibular fossa, and antero-inferior parts of the pyramids of the temporal bone, including the clivus.
2. The extended subtemporal approach provides an opportunity to remove tumours that spread within regions adjacent to the subtemporal fossa. In those cases the subtemporal fossa plays a role as a surgical approach route.
3. The extended subtemporal approach enables a planned identification of anatomical structures within the subtemporal fossa and its vicinity. Tumour resection with the extended subtemporal approach often requires maxillary artery ligation and maxillary and mandibular nerve amputations.
4. The larger the part of the tumour confined within the subtemporal fossa, the easier its removal via the extended subtemporal approach. The level of difficulty increases with extensive tumour penetration into the regions adjacent to the subtemporal fossa, especially the cavernous sinus and temporal bone pyramid.
5. Angiofibromas with their expansive growth proved to be the most feasible for removal among the tumours resected with the extended subtemporal approach. This feature was less frequent with meningiomas. Juvenile angiofibroma has a special place among tumours treated with the extended subtemporal approach due to its high vascularity. The main obstacle in surgical removal of malignant epithelial tumours en-bloc with healthy tissue margins was tumour penetration toward the cavernous sinus and orbital cone and, in particular, if it encompasses the internal carotid artery.

## Disclosure

Authors report no conflict of interest.

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