Open Transcranial Resection of Small (<35 mm) Meningiomas of the Anterior Midline Skull Base in Current Microsurgical Practice

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■ OBJECTIVE: **Despite technical surgical advance, the ultimate management of midline anterior skull base meningiomas remains to be defined. Open transcranial surgery is usually the first treatment option for large meningiomas, while less invasive techniques such as endoscopic surgery or radiosurgery might represent an alternative to open microsurgery for smaller lesions. The aim of our study is to investigate the outcome of open transcranial microsurgery in the resection of small (<35 mm) meningiomas of the midline anterior cranial base.**

■ METHODS: **Clinical and surgical data from 43 patients affected by small midline anterior skull base meningiomas operated via an open transcranial approach were retrospectively reviewed.**

■ RESULTS: **The tumor diameter on its major axis ranged from 12 to 35 mm, with a mean diameter of 28 mm. Gross total resection (Simpson grades I–II) was achieved in 100% of cases through a pterional approach. Postoperative overall morbidity was 9%. It was 3% among patients <70 years. No mortality was reported. Postoperative visual outcome was significantly associated with preoperative visual performance ($P = 0.02$), but not with preoperative optic nerve compression as detected by magnetic resonance imaging ($P = 0.116$). Age >70 years was associated with postoperative visual impairment, although not significantly ($P = 0.06$). Visual function was preserved or improved in 95% of cases, in 100% of patients <70 years, and in 71% of patients with preoperative visual impairment.**

■ CONCLUSIONS: **In our experience, open transcranial surgery proved safe and effective for midline anterior skull base meningiomas smaller than 35 mm in all patients <70 years and in patients >70 years without preoperative visual deficit. Our data are consistent with the literature. Conversely, the standard of treatment for the subgroup of patients >70 years with preoperative visual deficit has not yet been defined. This specific subgroup of patients offers a topic for further investigation.**

INTRODUCTION

Different treatment options are nowadays available for small (<35 mm) midline anterior skull base meningiomas (1-7, 13, 15-17, 23). Despite technical surgical advances, the lack of randomized trials renders the management of small midline anterior skull base meningiomas controversial (32, 34). Data regarding patient selection and outcome of each treatment modality may play a crucial role in defining the best management option for these lesions (7, 9, 13, 24, 31). Although there are growing data on endoscopic endonasal resection and radiosurgical treatment (3, 13, 15-17), there is lack of evidence in current literature regarding the outcome of transcranial resection

Key words
- Endoscopic
- Microsurgery
- Midline anterior fossa meningiomas
- Skull base
- Small meningiomas
- Surgical outcome

Abbreviations and Acronyms
ASA: Anaesthesiology Society Association
CSF: Cerebrospinal fluid
CT: Computed tomography
GTR: Gross total resection
MRI: Magnetic resonance imaging
OG: Olfactory groove
PS: Planum sphenoidale
STR: Sub total resection
TS: Tuberculum sellae
WHO: World Health Organization

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of small midline anterior skull base meningiomas (23). The aim of our study is to analyze our experience with open transcranial microsurgery in the resection of small (<35 mm) meningiomas of the midline anterior cranial base. We aim to investigate the outcome of open transcranial microsurgery in the resection of small (<35 mm) meningiomas of the midline anterior cranial base.

MATERIALS AND METHODS

Patients

Between January 2008 and October 2014 a total of 789 patients were operated on for intracranial meningiomas at the Department of Neurosurgery of Padua, Italy. Among them, 43 were affected by a midline anterior skull base meningioma with a diameter of less than 35 mm. Clinical and surgical data of these patients were retrospectively analyzed. Meningiomas were classified into olfactory groove (OG), tuberculum sellae (TS), and planum sphenoidale (PS) meningiomas; these last 2 groups were considered as a single cohort (TS/PS) for their similar clinical and surgical features. In all cases, surgery was indicated for the evidence of neurologic deficits or tumor growth (Table 1). A preoperative visual impairment was present in 7 cases, consisting in an isolated unilateral visual field deficit in 3 cases, a unilateral visual field deficit associated with a decrease in visual acuity in 2 cases, and a bilateral visual field deficit with a decrease in visual acuity in 2 cases. Endoscopic endonasal resection is not performed at our institution and is thus not available as a treatment option for meningioma of the anterior fossa. Open surgery was therefore the only surgical option offered to all the patients enrolled. Conversely, radiosurgery was considered the first treatment option for patients with severe comorbidities or those >80 years or refusing surgical treatment. Furthermore, only patients who were symptomatic, presenting with radiologic signs of lesion enlargement at follow-up, or affected by lesions with a diameter greater than 30 mm were considered for treatment. Patients were excluded from surgical intervention on the basis of age (>80 years) and comorbidities at high risk for transcranial surgery. Such risk was assessed by the anaesthesiology team according to the Anesthesiology Society Association (ASA) classification (exclusion from surgery when ASA >3). Patient data included surgical records, clinical charts, histological records, follow-up records, and imaging studies.

Imaging

All patients underwent magnetic resonance imaging (MRI) scans of the brain before surgery. Computed tomography (CT) was done in 27 patients. In 33 cases MRI angiography was performed in order to assess the vascular supply of the tumor and its relations with the main surrounding vessels. Digital subtraction angiography (DSA) was performed in 3 cases in which preoperative MRI showed an extensive involvement of main arteries, in order to assess the functional status of the involved vessels and to acquire preoperative data on vascular collateral circulation. In no case was preoperative embolization of the tumor feeders performed. An early postoperative CT scan was done in all cases. All patients had a postoperative MRI with gadolinium within 3 months from surgery.

SURGERY

Surgeries were all performed by the two senior surgeons (RS and ADP). Surgery was performed via an open transcranial pterional approach with the aid of operating microscope and microsurgical technique (37) (Figures 1 and 2). The extradural removal of the sphenoid ridge and the subsequent opening of the Sylvian fissure allowed a wide access between the frontal and the temporal lobe, with no need for brain retraction (see Figures 1 and 2). A self-holding spatula was used for brief times only when deeper and larger tumors were approached. Indeed, a cisternal opening usually enables the surgeon to obtain a "slack brain," which can be easily supported against gravity by using a suction device on top of a cottonoid with the left hand. As the tumor was exposed, its dural attachment was coagulated and sectioned. Afterwards, the tumor capsule was entered and the tumor was debulked (and decompressed) using microsurgical techniques. Lastly, the basal dura was coagulated or removed (see Figures 1 and 2). In the case of hyperostosis or bone infiltration, a diamond drill was used to remove the pathologic bone until healthy tissue was found. In particular, the pathologic bone was resected up to the extent that tissue with normal appearance under high magnification and with no pathologic bleeding was encountered. Whenever the ethmoidal and/or frontal sinuses were opened, autologous pericranial patch or temporalis muscle fascia were used for the reconstruction of the basal defect and prevention of cerebrospinal fluid (CSF) fistula. The patch was then reinforced with muscle or fat and then sealed with fibrin glue. The extent of tumor resection was stratified according to the Simpson classification (33). Our strategy was to use the frontopterional approach, even if both the unilateral subfrontal approach and the midline interhemispheric approach have proved to provide an excellent access to the anterior cranial base. Indeed, in our series the frontopterional approach allowed

Table 1. Clinical Features of Patients (the main clinical fact leading to surgery is indicated)

		Neurologic Deficit					
Location	Number of Cases	Visual disturbance	Headache	Seizure	Anosmia	Growth	Recurrence
	(Total 43)	7	4	2	5	16	9
Olfactory groove	20	0	1	2	5	6	6
Tuberculum sellae	23	7	3	0	0	10	3

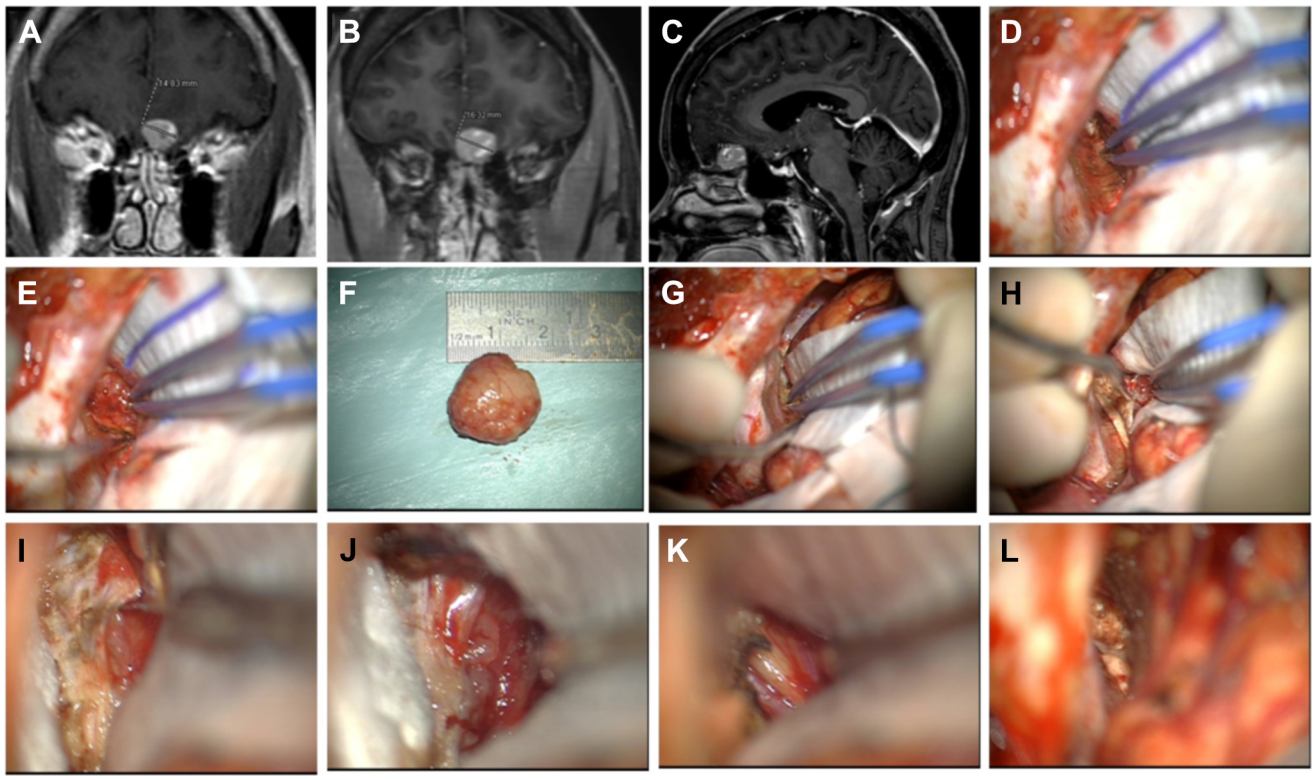

Figure 1. A 47-year-old female patient affected by an olfactory groove (OG) meningioma. She came to our attention for seizure. Magnetic resonance imaging (MRI) showed a small (14.83-mm diameter) (**A**: T1-weighted image after gadolinium (Gd) OG meningioma. Because of the tumor's small size, the patient was managed conservatively. However, after 6 months, a second MRI (**B**–**C**: axial and coronal T1-weighted images after Gd) showed a progression of tumor (now presenting a 16.32-mm diameter). For this reason, the patient underwent surgery. Intraoperative microscopic images (**D**–**L**): after a left pterional craniotomy and a partial sylvian fissure dissection to obtain a slack brain, the dural attachment of meningioma was coagulated and sectioned (**D**). Then the tumor was removed (**E**–**F**). The falx was coagulated (**G**) and sectioned (**G**–**H**) in order to explore the contralateral (right) anterior cranial base and remove the contralateral residual tumor (**I**–**J**). Final view of right gyrus rectus and olfactory nerve (**K**). The basal dura of the anterior fossa was finally removed and underlying bone was partially drilled out (**L**). The left olfactory nerve was preserved (**E, H**) and protected by a piece of Gelfoam when approaching the right anterior fossa (**I, J**).

an early and safe control of both the internal carotid artery (ICA) and the optical nerve just posterior to the tumor and enabled a safe unroofing of the optic canal, having the ICA under direct view.

Research Variables

Extent of resection and postoperative morbidity data were analyzed. After discharge, patients were followed in the outpatient clinic at 3 and 6 months and then at 1- to 2-year intervals depending on the histological grade and extent of removal. To the purpose of assessing morbidity, the postoperative complications and new neurologic deficits that we evaluated were the same considered previously by other authors in midline anterior skull base meningioma case series managed with alternative treatments (15). The postoperative complications evaluated in this study were CSF leak, wound infection, hydrocephalus, hygroma, meningitis, brain abscess, postoperative hematoma, permanent diabetes insipidus, and postoperative cerebral edema. The new neurologic deficits evaluated were anosmia, visual deficit, balance impairment, cranial nerve palsy, frontal syndrome, and memory deficits. Preoperative neurologic deficits were reassessed postoperatively and registered as improved, stable, or worsened. The impact on surgical outcome of location of the meningioma, age (<70 years and >70 years), and preoperative visual deficit was also evaluated.

Statistical Analysis

Data were compared using the Fisher's exact test (expected unfavorable visual outcomes frequencies <5). A *P* value was calculated for each comparative analysis, with significance assumed at the 0.05 level. All analyses were performed with SPSS (Version 22; IBM, Inc).

RESULTS

Clinical and Radiological Features

Data are summarized in **Table 1**. Forty-three patients were enrolled in the study: 20 with olfactory groove (OG) meningiomas and 23 with TS/PS meningiomas. Twenty-nine (67%) were female and 14 (33%) were male, with a mean age of 63 years (range from 38–81). Surgical treatment was indicated for the onset of a neurologic

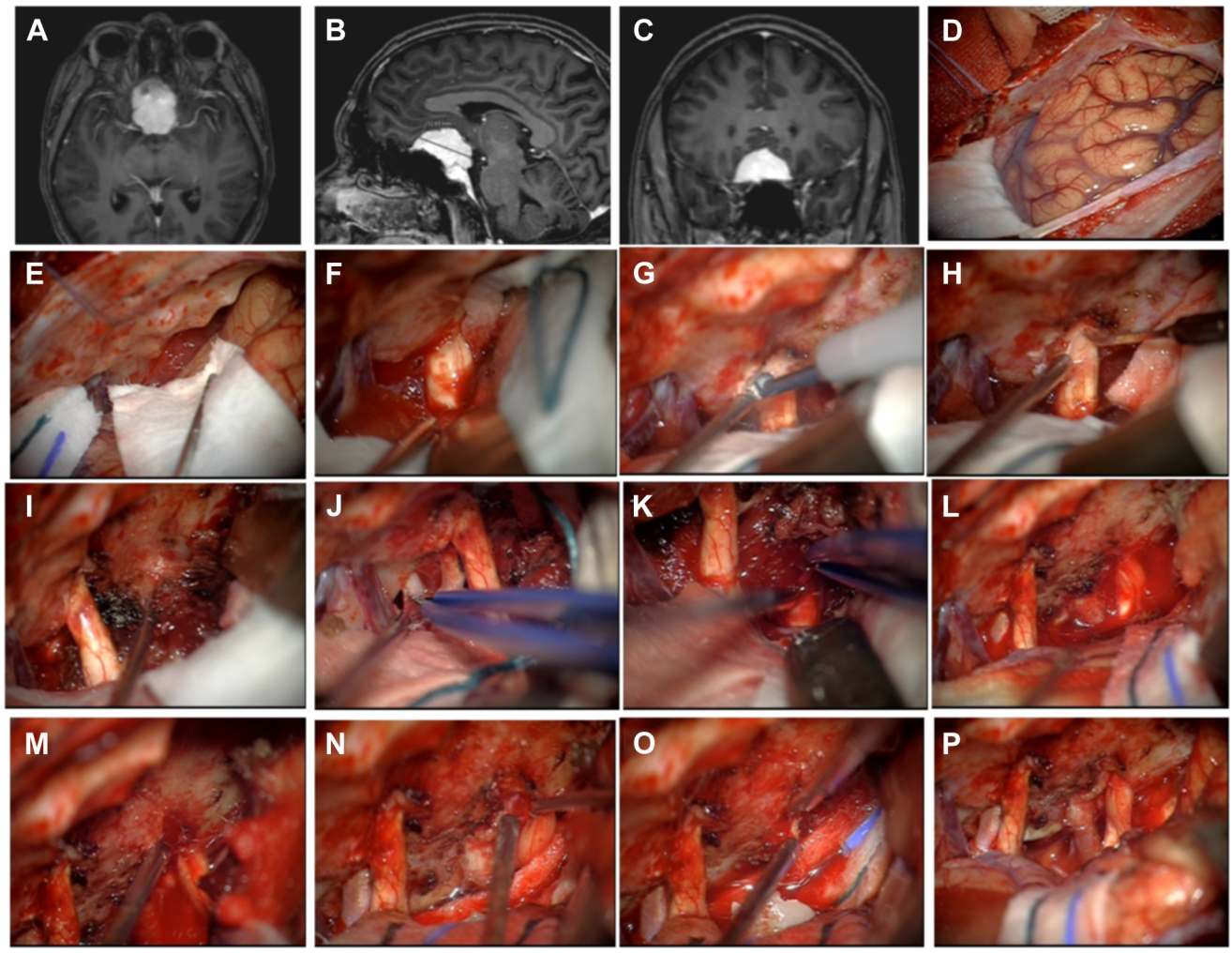

Figure 2. A 53-year-old female patient affected by a suprasellar meningioma arising from the planum sphenoidale (**A**–**C**: axial, sagittal, and coronal T1-weighted images after gadolinium administration). Intraoperative microscopic images (**D**–**P**): brain exposure after left pterional craniotomy (**D**); meningioma exposure after brain relaxation because of partial sylvian fissure dissection (**E**). Images showing the left optic nerve exposure (**F**), ultrasonic unroofing of left optic canal (**G**), and optic nerve decompression by dural sheath opening (**H**). Planum sphenoidale dural attachment was coagulated, and then the median tumor component was removed (**I**–**K**) dissecting the oculomotor nerve (**J**) and exposing the contralateral optic nerve (**L**). The contralateral optic canal was then opened and the intracanalar component of the meningioma was finally removed (**M**–**O**). Final view (**P**).

deficit in 44% of cases (19 patients), for the evidence of tumor growth at radiological follow-up of an incidental lesion in 35% of cases (15 patients), and for recurrent disease in 21% of cases (9 patients). Patients with recurrent disease presented a World Health Organization (WHO) grade I in 7 cases and a WHO grade II in 2 cases. At the preoperative radiological assessment, hyperostosis was observed in 12 out of the 27 patients (44%) in whom a CT head scan was performed. MRI features of optic nerve compression were observed in 8 out of 43 cases (49%). In 6 cases the tumor invaded the paranasal sinuses. Peritumoral edema was observed in 26 patients (60%) on CT or MRI scans. The tumor diameter on its major axis ranged from 12–35 mm, with a mean diameter of 26 mm; it was larger in OG meningiomas (range 16–35, mean 28 mm) than in TS meningiomas (range 14–34, mean 25 mm). The surgical approach was from the right side in the majority of cases (36 patients), unless tumor extension toward the left side was clearly prevailing (7 patients).

SURGICAL OUTCOME

Morbidity and Mortality

Data are summarized in Table 2. No mortality was reported. Overall morbidity was 9.2% (5% in OG and 12.9% in TS/PS meningioma patients, respectively). The postoperative complication rate was 4.6% (2 patients): 5% in OG and 4.3% in TS/PS meningiomas, respectively. In one case of TS/PS meningioma an external lumbar drainage was inserted after surgery because of a subcutaneous CSF collection, which resolved after a few days; no rhinoliquorrhea occurred. The patient with a recurrent OG meningioma underwent a shunt

Table 2. Postoperative Course of Patients

	Location of Meningioma			Age	
Postoperative Course	**OG Patients 20**	**TS Patients 23**	**All Patients 43**	**<70 Years 32**	**> 70 Years 11**
Complications					
CSF leakage	0	1 (4.3%)	1 (2.3%)	0	1 (9%)
Wound infections	0	0	0	0	0
Meningitis	0	0	0	0	0
Hydrocephalus	1 (5%)	0	1 (2.3%)	1 (3%)	0
Brain abscess	0	0	0	0	0
Hemorrhage	0	0	0	0	0
Permanent DI	0	0	0	0	0
Increased edema	0	0	0	0	0
Total	1 (5%)	1 (4.3%)	2 (4.6%)	1 (3%)	1 (9%)
New Neurologic Deficits					
Hemiparesis	0	0	0	0	0
CN palsy					
I	0	0	0	0	0
II	0	0	0	0	0
III	0	0	0	0	0
Frontal syndrome (stroke)	0	0	0	0	0
Memory impairment	0	0	0	0	0
Total	0	0	0	0	0
Deficit Worsening					
Hemiparesis	0	0	0	0	0
CN palsy					
I	0	0	0	0	0
II	0	2 (8.6%)	2 (4.6%)	0	2 (18%)
III	0	0	0	0	0
Frontal syndrome (stroke)	0	0	0	0	0
Memory impairment	0	0	0	0	0
Total	0	2 (8.6%)	2 (4.6%)	0	2 (18%)
Overall Morbidity					
Total	1 (5%)	3 (12.9%)	4 (9.2%)	1 (3%)	3 (27%)
Perioperative Mortality					
Total	0			0	0

OG, olfactory groove; TS, tuberculum sellae; CSF, cerebrospinal fluid; DI, diabetes insipidus; CN, cranial nerve.

procedure for hydrocephalus. No new neurologic postoperative deficits were reported. The postoperative worsening of a preexisting neurologic impairment occurred in 4.6% of cases (8.6% of TS meningiomas). Indeed, 2 patients affected by a TS meningioma experienced a visual impairment after surgery. With regard to the 12 patients (28% of total) with preoperative cranial nerve palsy (Table 3), 4 (33%) improved, 6 (50%) remained stable, and 2 (17%) worsened. Neurologic deficits remained stable in all OG patients. With regard to visual function, among the 8 TS patients who presented with features of optic nerve involvement at preoperative MRI without visual impairment, none had postoperative worsening; conversely, in

Table 3. Postoperative Course of Patients Focusing on Visual Outcome

	Research Variables				
	Location of Meningioma			Age	
Postoperative Course	OG	TS	Total	<70 years	>70 years
1. Visual Outcome of Patients					
Total patients (43)					
Improved	0	4 (17%)	4 (9%)	4 (12%)	0 (%)
Stable	20 (100%)	17 (74%)	37 (86%)	28 (88%)	9 (82%)
Deteriorated	0	2 (9%)	2 (5%)	0 (%)	2 (18%)
Total	20	23	43	32	11
With preoperative ON compression (8) (and no ON deficit)					
Improved	-	-	-	-	-
Stable	0	8 (100%)	8 (100%)	5 (100%)	3 (100%)
Deteriorated	0	0	0	0	0
Total	0	8	8	5	3
With preoperative ON deficit (7)					
Improved	0	4 (57%) 1(14%)	4 (57%)	3 (75%)	0
Stable	0	2 (29%)	1 (14%)	1 (25%)	1 (33%)
Deteriorated	0		2 (29%)	0	2 (67%)
Total	0	7	7	4	3
2. Deficit Worsening					
In patients with P/O deficits (12)	5 (In palsy)	7 (IIn palsy)	12	7	5
Hemiparesis	0	0	0	0	0
CN palsy	0	2 (29%)	2 (17%)	0	2 (40%)
I	0	0	0	0	0
II	0	2 (29%)	2 (17%)	0	2 (40%)
III	0	0	0	0	0
Frontal syndrome (stroke)	0	0	0	0	0
Memory impairment	0	0	0	0	0
Total worsened	0	2 (29%)	2 (17%)	0	2 (40%)

OG, olfactory groove; TS, tuberculum sellae; ON, olfactory nerve; CN, cranial nerve; In Palsy, first nerve palsy; IIn Palsy, second nerve palsy.

the 7 TS patients with preoperative visual impairment, the visual function remained stable in 14%, deteriorated in 29%, and improved in 57% of cases (see Table 3). In particular, both the patients with bilateral visual field deficit with a decrease in visual activity worsened; among the 3 patients with the isolated unilateral visual deficit, 2 improved and 1 remained stable; the 2 patients with the unilateral visual deficit with decrease in visual acuity improved. The 2 patients who presented with seizures recovered completely after surgery with no need of antiepileptic drugs for seizure control. In our series, 11 patients were older and 32 were younger than 70 years. Postoperative complications occurred in 9% of the older than 70 years and in 3% of the younger than 70 years subgroup, while worsening of a preoperative neurologic deficit occurred in 18% of the patients of the older and in none of the younger subgroup (see Table 2). Among the 7 TS patients with preoperative visual impairment, the visual function of patients older than 70 years deteriorated in 67%, remained stable in 33%, and improved in none; conversely, patients younger than 70 years improved in 75%, were stable in 25%, and deteriorated in no case. There was a statistically significant association between preoperative visual performance and postoperative visual outcome ($P = 0.02$) in the overall cohort of patients. Postoperative visual outcome was favorable (preserved or improved) in patients whose visual

function was preoperatively intact or slightly affected. Age >70 years was associated with postoperative visual impairment, although not significantly ($P = 0.06$). The 2 patients with postoperative deterioration presented a preoperative visual impairment and were older than 70 years. Visual outcome was preserved or improved in 95% of all cases, in 100% of patients <70 years, and in 71% of patients with preoperative visual impairment. Preoperative optic nerve compression in TS meningiomas ($n = 15$ patients) was not significantly associated with postoperative visual outcome ($P = 0.116$).

Resection and Follow-up

The follow-up period for all patients ranged from 3 to 77 months (mean, 41 months). Complete tumor removal was achieved in all patients (Simpson grades 1 or 2). In 23 out of 43 patients (53%), infiltrated dura was removed (Simpson grade I); among these 23 cases, in 9 (20%) bone invasion was drilled out. In 20 patients (47%) infiltrated dura was only coagulated (Simpson grade II). Histological examination revealed that 41 (95%) meningiomas were WHO grade I, and 2 (5%) were WHO grade II. Follow-up data were available for 25 out of 43 patients (58%), and recurrent disease occurred in 2 patients (8%). The histological grade of recurrences was WHO I in one case and WHO II in the other. The mean time for recurrence was 16 months. The 2 recurrences were managed conservatively because both were small (<10 mm) and asymptomatic. In the remaining 21 patients clinical and radiological follow-up showed no signs of recurrent disease.

DISCUSSION

Literature Review on Different Surgical Options for Midline Anterior Fossa Meningiomas

A huge amount of data is available in literature on anterior skull base meningiomas surgery, focusing on different issues such as location, size, new strategies, and innovative techniques (1-32, 35, 36). A gross total resection (GTR) (Simpson grades I or II) rate of around 90% in anterior skull base meningioma was reported in recent series (1, 11, 21, 22, 28). Over the past decades, skull base approaches have been advocated in order to maximize resection and minimize brain retraction (29). Nevertheless, cranial base approaches are burdened by specific morbidity related to sinus opening and venous sacrifice. A surgical complication rate of 20%–30% has been reported in anterior skull base tumor surgery (1, 11, 22, 28), with a mortality rate between 0% and 5% (1, 8, 11, 22, 28). In fact, the indication for open surgery in the resection of anterior large and giant meningiomas is not debated, regardless of whether the chosen approach is skull base or not. Conversely, as far as smaller meningiomas (<35 mm) are concerned, the role of open surgery is argued. Endoscopic endonasal approaches have been recently proposed as a feasible and less invasive option for small midline meningiomas with limited lateral extension (4-6, 10, 14, 25, 34-36), yet its role remains controversial (32, 34). Favorable visual outcome (improved or spared) is supported by both transcranial open surgery, for the opening of the optic canal and early identification of the optic nerve (18, 19, 23) and endonasal endoscopic approaches thanks to minimal manipulation of the optic apparatus (4-6, 14, 16, 36). Contrasting data on visual outcome are reported in current reviews (2, 15) (**Table 4**). Such data are not homogeneous

Table 4. Comparison Between Literature Data (15) and Data from the Present Study

Meningioma	Tumor Characteristics		Preoperative Visual Disturbance	Extent of Removal		Complications			Postoperative Visual Outcome		Mortality
	Mean Lesion Diameter (mm)	Previous Surgery		GTR	STR/ Partial	New CN Palsy	HP	CSF Leak	Improved/ Preserved	Deteriorated	
OG											
From literature											
Open	380	6.5%	32%	92.8%	7.2%	5.8%	4.2%	6.0%	95.7%	4.3%	3.3%
Endoscopic	—	20%	42.1%	63.2%	36.8%	0	0	31.6%	100%	0	0
Present Study	280	30%	0	100%	0%	0	5%	0	100%	0	0
TS											
From literature											
Open	283	12.2%	83%	84.1%	15.9%	0.5%	0	4.3%	85.8%	14.2%	2.0%
Endoscopic	270	16.7%	80.4%	74.7%	25.3%	0	0	21.3%	87.3%	12.7%	3.0%
Present Study	250	13%	30.4%	100%	100%	0	0	4.3%	91%	9%	0

GTR, gross total resection; STR, subtotal resection; CN, cranial nerve; HP, Hydrocephalus; CSF, cerebrospinal fluid; OG, olfactory groove; TS, tuberculum sellae.

and hardly comparable for different tumor size, degree of visual compromise at presentation, duration of visual symptoms, patient age, and follow-up features (19, 20, 26, 27, 30). Unfortunately, the available data of the outcome related to the endoscopic endonasal technique derive from small series (generally studies with <20 patients) with limited follow-up and are burdened by selection bias (12, 15, 31, 32). In two recent reviews (12, 15), endoscopic endonasal GTR was reported, respectively, in 63% and 73% of olfactory groove and in 74% and 56% of TS meningiomas. Postoperative cerebrospinal fluid (CSF) leak and infection rates were high. Postoperative CSF leak was reported (respectively) in 30%–31% of olfactory groove and 14%–25.3% of TS meningiomas (10, 12, 15, 16). Relatively high rates of pituitary insufficiency were reported in some endoscopic transnasal series: 14%–20% rate of permanent diabetes insipidus and up to a 7.7% rate of panhypopituitarism were observed (15). Komotar et al. recently compared the outcomes of endoscopic endonasal to open transcranial route in resection of midline anterior skull base meningiomas; by reviewing 60 studies involving 1426 patients, the authors showed that open surgery achieved a higher rate of GTR ($P < 0.01$), while endoscopic resection presented a higher CSF leak rate ($P < 0.01$) (15). Postoperative complications and visual outcome did not differ between the two groups. However, the authors duly observed that the mean tumor diameter was greater in the open surgery cohort, and that could be a main limitation of their study. At present, there is a lack of studies focusing on the outcome of open surgery in smaller meningiomas (23).

Our Findings

In our 43-patient series, overall morbidity was 9.2%. Two considerations should be done with respect to the morbidity in our series. Firstly, it was age related. Indeed, it was 27% and 3% in patients, respectively, older or younger than 70 years old (see **Table 2**). The rate of postoperative visual function worsening ranged from 18%–0% according to the patient age (see **Table 3**). Secondly, morbidity was also strictly related to the preoperative neurologic status. A postoperative neurologic worsening was reported in 17% of patients presenting with a preoperative impairment, whereas none of the patients with a normal preoperative neurologic examination had a postoperative deterioration. More in detail, 29% of TS meningioma patients with a preoperative visual deficit presented a postoperative worsening. Despite the high postoperative worsening rate among patients with a preoperative deficit, we should bear in mind that more than 57% of the TS patients presenting a preoperative visual impairment improved after surgery. In no case could a postoperative deficit be related to surgery-related brain injury. This is a remarkable point, if we consider that one of the main advantages of alternative treatment options is the avoidance of brain retraction (16). A potential explanation of this is that small tumors require a minor or absent brain retraction during open surgery. Finally, we would like to highlight the 100% rate of GTR (Simpson grades I or II) achieved in our case series. These data must be otherwise reminded if we consider that this outcome is not easily achievable by an endoscopic approach and, by definition, is not the aim of radiosurgery; in this perspective, both these approaches bear deep limitations in their overall "cure" of patients.

Significance of Our Study

Studies focusing on small midline anterior skull base meningiomas are lacking. Therefore our study represents one of the few works available for an objective assessment of open surgery. On the basis of our retrospective data, we can postulate that open cranial surgery (through a pterional approach) presents a high rate of cure with a reasonably low morbidity. In particular, our findings show that the lower the size of the meningioma, the better the outcome. The GTR rate (100%) was higher and morbidity was lower (5 and 12.9% for OG and TS, respectively) in our study on small meningiomas (tumor mean diameter 28 and 25 mm, range 16–35 mm and 14–34 mm for OG and TS, respectively) than in other studies on open surgery (tumor mean diameter 38 and 28 mm, range 11–67 mm and 23–70 mm for OG and TS, respectively) reported in the literature (GTR 92% and 84%, morbidity 38% and 25% for OG and TS, respectively) (15). The larger size of TS meningiomas reported in the literature may explain the higher rate preoperative visual disturbance (83%, as compared with 30% in our study) and consequently the different postoperative visual outcome (58% improved, 27% stable, 14% worsened in the literature; 17% improved, 74% stable, 9% worsened in our study). Our study is retrospective and contains a selection bias because endoscopy is not a treatment option for meningiomas at our institution. Our research variables were deliberately defined in order to provide a homogeneous case series eventually comparable with other studies focusing on different techniques. As far as surgical outcome is concerned, two main considerations emerge from our study. First, in our series, the mean age was 63 and the overall morbidity was 9.2%. However, after dichotomizing our patients on the basis of age (younger and older than 70 years) we could obtain two distinct cohorts, with completely different features: a first cohort of 32 patients with a mean age of 54 years and an overall morbidity of 3% (1/32 patients) and a second cohort of 11 patients with a mean age of 73 years and a morbidity of 27% (3/11 patients). The second consideration concerns the importance of preoperative visual function in TS meningiomas. No significant differences in visual outcome between open and endoscopic series of TS meningiomas are reported in the literature (15). A comparison between data from our series and data from the literature (15) is reported in **Table 4**. Given the low occurrence of preoperative visual impairment in our series (30%, against more than 80% reported in the literature for TS patients), we stratified the postoperative visual outcome in the table in "improved/stable" and "deteriorated." In our study 17% of TS patients improved, 74% were stable, and 9% deteriorated (91% improved/stable vs. 9% deteriorated). However, the outcome findings change if stratified according to preoperative visual function and age. There was a statistically significant association between preoperative visual performance and postoperative visual outcome ($P = 0.02$) in the overall cohort of patients. Indeed, patients with a preoperative visual impairment improved in

57%, were stable in 14%, and deteriorated in 29%. Patients with no preoperative impairment remained stable postoperatively in 100% of cases. Furthermore, dividing the preoperative visual impairment group in a subgroup younger and a subgroup older than 70 years, we found that the former improved in 75% and remained stable in 25%, while the latter deteriorated in 67% and remained stable in 33% of cases. Preoperative optic nerve compression in TS meningiomas ($n = 15$ patients) was not significantly associated with postoperative visual outcome ($P = 0.116$). Both patients with TS meningioma who suffered from postoperative visual deterioration were >70 years and presented a preoperative visual defect. Our findings suggest that selected patient groups could particularly benefit from open surgery, while other patients (>70 years and with preoperative visual impairment) could be more successfully managed by a different route and should be considered for different treatment options. A possible explanation of a worse visual outcome in elderly patients could be the age-related more fragile vascular supply to the optic-chiasmatic system, which might be more vulnerable to manipulation in this age group. In light of such a remark, the use of a transsphenoidal approach in the elderly should be regarded as a valid alternative option. Indeed, the transnasal technique allows a lesser degree of optic nerve manipulation and an early interception of the feeding arteries, and it could assist in reducing optic pathways ischemia. We must keep investigating in order to provide a tailored treatment according to patient and tumor features.

CONCLUSIONS

Despite technical and scientific progress, the best management of small meningiomas of the midline anterior cranial fossa remains controversial. In our experience, open transcranial surgery proved safe and effective for midline anterior skull base meningiomas <35 mm in all patients <70 years and in patients >70 years without preoperative visual deficit. Our data are consistent with the literature (15). Conversely, the standard of treatment for the subgroup of patients >70 years with preoperative visual deficit has not yet been defined. This specific subgroup of patients offers a topic for further investigation. Finally, we do emphasize that the management options should take into account the surgeon's own experience with the different approaches and techniques (microsurgical, endoscopic, combined).

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