




Pterional Approach for Anterior Skull Base Midline Meningiomas against “The More The Merrier” Approach: An Institutional Experience

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Abstract

Objective Anterior midline skull base meningiomas involving olfactory groove, planum sphenoidale, and tuberculum sellae were usually managed with bifrontal craniotomy until the dawn of advanced microsurgical techniques. With the emergence of microsurgical techniques, midline meningiomas could be tackled solely from a unilateral pterional approach. We present our experience with pterional approach in managing anterior skull base midline meningiomas, including the technical nuances and outcomes.

Methods Fifty-nine patients who underwent excision of anterior skull base midline meningiomas through a unilateral pterional craniotomy between 2015 and 2021 were retrospectively analyzed. The surgical technique and patient outcomes in the context of visual, behavioral, olfaction, and quality of life were evaluated during the follow-up.

Results A total of 59 consecutive patients were assessed over an average follow-up period of 26.6 months. Twenty-one (35.5%) patients had planum sphenoidale meningioma. Olfactory groove and tuberculum sellae meningioma groups consist of 19 (32%) patients each. Visual disturbance was the predominant symptom with almost 68% of patients presented with it. A total of 55 (93%) patients had complete excision of the tumor with 40 patients (68%) achieving Simpson grade II excision, and 11 (19%) patients had Simpson grade I excision. Among operated cases, 24 patients (40%) had postoperative edema among which 3 (5%) patients had irritability and 1 patient had diffuse edema requiring postoperative ventilation. Only 15 (24.6%) patients had contusion of the frontal lobe and were managed conservatively. Five patients (50%) with seizures had an association with contusion. Sixty-seven percent of patients had improvements in vision and 15% of patients had a stable vision. Only eight (13%) patients had postoperative focal deficits. Ten percent of patients had new-onset anosmia. The average Karnofsky score was improved. Only two patients had recurrence during follow-up.

Keywords

- ▶ anterior midline skull base meningioma
- ▶ olfactory groove
- ▶ planum sphenoidale
- ▶ pterional approach
- ▶ tuberculum sella

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Conclusion A unilateral pterional craniotomy is a versatile approach for the excision of anterior midline skull base meningioma, even for the larger lesions. The ability of this approach in the visualization of posterior neurovascular structures at the earlier stages of surgery while avoiding the opposite frontal lobe retraction and frontal sinus opening makes this approach more preferable over the other approaches.

Introduction

Of all the burden of intracranial neoplasms, one-third of lesions are meningiomas.¹ Olfactory groove meningioma (OGM), planum sphenoidale meningioma (PSM), and tuberculum sellae meningioma (TSM) constitute the anterior midline skull base meningiomas (AMSBM). Skull base constitutes almost one-fourth of all the intracranial meningiomas.² Of the 25% skull base meningiomas, 4 to 18% are OGM,³ and 5 to 10% are PSM and TSM.^{4,5} Since the early descriptions regarding the management of these lesions by Sir William MacEwen, many approaches and their modifications have been proposed to tackle these lesions along with the advent of microsurgical techniques.⁶ Cushing⁷ described a unilateral frontal craniotomy for excising these lesions; later Dandy went on to do bifrontal craniotomy and transbasal modifications along with partial frontal lobectomies to counter edema and contusions.⁸ Hassler and Zentner⁹ described pterional approach for these lesions and later popularized by Yasargil.¹⁰ Additionally, frontolateral approach, extended pterional approach^{11,12} with lateral orbitotomy and orbitozygomatic osteotomy, inter-hemispheric approach,^{13,14} mini pterional, and more recently supraorbital keyhole approach (microscopic or endoscope assisted) have been tried.¹⁵ Endoscopic endonasal approach is increasingly studied over the past decade.¹⁶ The choice of such approaches is individualized based on the surgeon's discretion. Recently Aftahy et al¹⁷ proposed an algorithm for approach to AMSBM. We present to you our institutional experience in approaching these tumors through pterional craniotomy.

Materials and Methods

Inclusion and Exclusion Criteria

The study was conducted as a single-center observational retrospective study at the Department of Neurosurgery, Sree Chitra Tirunal Institute for Medical Sciences and Technology. Patients who underwent surgery for AMSBM via pterional approaches between January 2015 and December 2021 were included. Entities other than meningiomas, cases operated through other approaches, and lateral skull base meningiomas were excluded. All our patients were subjected to contrast computed tomography scan in the immediate postoperative period. Then, during follow-up, yearly, a contrast magnetic resonance imaging will be done to look for any recurrence. The institution ethical committee clearance was obtained. As our study involves midline meningiomas, clinoidal meningiomas being relatively laterally placed and the growth pattern more of

laterally projecting type, clinoidal meningiomas were excluded from this study.

Outcome Parameters

The demographic and patient clinical data was obtained from electronic medical records of the institute. Clinical records were evaluated for preoperative neurological symptoms, Karnofsky Performance Scale (KPS), neurological deficits, complications, and reinterventions for the same. Operative records were analyzed and degree of excision, optic nerve status/decompression, and difficulties during surgical approach were collected. All patients had undergone regular postoperative imaging on outpatient basis and were analyzed for residual and recurrence.

Statistical Analysis

Mean and range are used to describe continuous variables. Categorical variables are denoted as frequency. Continuous variables are compared using independent *t*-test, Pearson's chi-square test, and analysis of variance. A *p*-value of less than 0.05 was taken as statistically significant.

Results

Patient Demographics

A total of 59 patients diagnosed with AMSBM underwent excision via pterional approach of which, 35.5% ($n = 21$) patients had PSM and 32% ($n = 19$) patients were diagnosed with OGM and TSM. Forty-five (76%) patients were female. Sixty percent ($n = 36$) patients belonged to the 40 to 60 years age group, and the mean age is 50.11 years (21–74 years) (► **Table 1**).

Clinical Features

Predominant presenting symptom was visual disturbance in 68% ($n = 40$) patients followed by headache (64.4%), memory disturbance (58%), anosmia (33.8%), and seizures (19%). Among the 19 OGM patients, headache (78%) and anosmia were the main presenting complaints. In PSM and TSM, visual disturbances ($n = 17$ each) were the predominant symptom. The average preoperative KPS was 75.6 (40–90) and the average tumor size was 38 mm (14–72 mm). Twenty-four (40.6%) patients had tumors more than 40 mm in size and 28% ($n = 17$) had tumors between 20 and 30 mm maximum dimension (► **Table 2**).

Tumor Characteristics and Surgery

All patients underwent pterional craniotomy and excision of the lesion. Excision of meningioma was graded as per

Simpson’s grading. In lesions with optic canal extension or optic nerve compression, additional optic canal decompression was performed. Seventeen (28%) patients underwent surgical decompression from the left side in view of the anatomical characteristics of the tumor and its location. Seventy-two percent ($n=42$) patients underwent right pterional approach. None of the patients required additional maneuvers like lateral orbitotomy or zygomatic osteotomy.

About 93.7% ($n=55$) patients had complete excision of the tumor (Simpson I, II, and III). Forty patients (68%) had grade II Simpson excision, whereas 11 (19%) had grade I excision. Forty-one (69%) patients had World Health Organization (WHO) grade I meningiomas and the rest had WHO grade II.

Additional optic nerve decompression was performed in 11 patients (19%) following. Of these, 10 patients had TSM. Additional removal of the anterior clinoid process to increase visualization was done in five TSM patients. Three patients underwent additional drilling of the hyperostotic bone.

Outcomes and Adverse Events

Immediate Postoperative Period

Twenty-four patients had postoperative edema on imaging, among which 20 (33%) patients had mild edema without mass effect, and one (1.6%) with severe edema requiring antiedema measures and postoperative ventilation. No patient had extradural or subdural collections. Fifteen patients had evident frontal lobe contusions in the postoperative imaging that needed no further surgical intervention. Another common immediate postoperative manifestation was seizures ($n=10$), while half of them had mild frontal contusions.

Visual outcomes: 27 (67%) patients had visual improvements compared to the pre-operative status, whereas six (15%) had stable vision. Only one patient had deterioration postoperatively owing to the severely stretched and thinned-out optic nerve. We have assessed visual status clinically, by confrontation. Same Confrontation method was used to assess the visual status during the follow-up. Perimetry evaluation was not possible uniformly in the study group because of the pandemic, which forms the limitation of our study.

Olfaction: 10% ($n=6$) patients developed anosmia postoperatively.

Focal deficits: A total of 8 patients had new focal deficits. Three (5%) patients had transient third nerve palsy, three developed behavioral disturbances, and two (3.3%) had hemiparesis that improved on postoperative rehabilitation.

Cerebrospinal fluid (CSF) leak: One patient in the study group developed postoperative CSF leak, which was managed conservatively with lumbar drain insertion.

KPS: Average KPS had improved from 75.6 to 78, postoperatively ($p=0.32$).

Mortality

Two mortalities were noted in our study (3.3%). One, developed diffuse cerebral edema and associated herniation and

the other, had anterior cerebral artery (ACA) and middle cerebral artery (MCA) territory infarct.

Follow-Up and Recurrence

The average follow-up duration was 29.5 (4–79) months. Two patients (3.3%) developed recurrence of lesion during follow-up (24–40 months). Both these patients had PSM and WHO grade II histology. Three patients (5%) had stable residue during follow-up.

Outcomes-Based on Different Anatomical Locations and Pathological Diagnosis

Patients with OGM had headache as the main symptom. Fourteen patients (73%) had lesions of size of 40 mm or above. In 17 (90%) patients, complete excision was achieved despite large size and extension to the opposite side. Among them, four (21%) patients had grade I excision. Three patients (15%) had significant postoperative edema and three patients had frontal lobe contusions. The associated seizures could be attributed to the larger lesions in three-fourths of these patients. One patient (5%) expired due to diffuse cerebral edema and postoperative seizures. Excluding this patient, KPS had improved to 81. Four patients developed new onset anosmia. Bony hyperostosis was addressed with drilling of the bone in one patient (► Tables 3–5).

PSM patients predominantly had visual disturbances. Complete excision was achieved in 19 patients (90.5%); one requiring optic foramen deroofting. Eleven patients (64%; $p=0.07$) had visual improvement. One (4.7%) had significant brain edema. Contusion was seen in five patients. Two (9.5%) patients had associated seizures. Two of the patients (3%) with WHO grade II lesions had recurrence later. One patient had pulmonary thromboembolism, a month after surgery and succumbed.

In TSM patients, gross total excision achieved in all patients (100%) and grade I excision in four. Two patients underwent hyperostotic bone drilling. Visual improvement was documented in 70% ($n=12$; $p=0.108$) patients and six required optic foramen deroofting. Totally, ten (58.8%)

Table 1 Patient demographics and clinical characters

Character	Mean (range or percentage)
Age	50.11 (21–74) years
Sex	
Male	14 (24%)
Female	45 (74%)
Karnofsky score	74.5 (40–90)
Clinical presentation	
Visual disturbances	40 (67.7%)
Headache	38 (64.4%)
Memory disturbances	23 (58%) (among 39 patients)
Olfactory disturbances	20 (33.8%)
Seizures	11 (19%)

Table 2 Clinical presentation in different pathologies

	Total number	Headache	Visual disturbances	Anosmia	Memory disturbances	Seizures
Olfactory groove meningioma	19	15 (78%)	07	13	11	06
Planum sphenoidal meningioma	21	13	17 (80%)	07	11	03
Tuberculum sella meningioma	19	10	17 (89.4%)	03	02	02

Table 3 Outcomes in different anatomical location

	Vision improved	Postoperative edema	Contusion	Seizures	Mortality	Recurrence
Olfactory groove meningioma	05 (71%)	08 (42%)	09 (47%)	05 (26%)	01 (1.6%)	Nil
Planum sphenoidal meningioma	11 (64%)	05 (23%)	04 (19%)	03 (14%)	01 (pulmonary thromboembolism)	02 (3%)
Tuberculum sella meningioma	12 (70%)	08 (42%)	02 (10%)	01 (5%)	01	Nil

Table 4 Tumor histology and Simpson grade of excision

Entity	Grade	OGM	PSM	TSM
Simpson grade	I	04 (21%)	03(14.3%)	04
	II	12 (63%)	16 (76%)	12
	III	01 (5.2%)	00	03 (15.7%)
	IV	02 (10.5%)	02 (9.5%)	00
WHO grade	I	12 (63.15%)	13 (61.9%)	16 (84%)
	II	07 (36.8%)	08 (38.1%)	03 (15.7%)
	III	00	00	00

Abbreviations: OGM, olfactory groove meningioma; PSM, planum sphenoidale meningioma; TSM, tuberculum sella meningioma; WHO, World Health Organization.

Table 5 Clinical outcomes

Location	Components			p-Value
Olfactory groove	Vision	Preoperative impaired	7	0.82
		Postoperative improved	5	
	KPS	Preoperative	77.3	0.33
		Postoperative	80	
GOS	Postoperative	3.21		
Planum sphenoidale	Vision	Preoperative impaired	17	0.07
		Postoperative improved	11	
	KPS	Preoperative	71.4	0.19
		Postoperative	76.6	
GOS	Postoperative	3.45		
Tuberculum sellae	Vision	Preoperative impaired	17	0.108
		Postoperative improved	12	
	KPS	Preoperative	75.7	0.38
		Postoperative	77.8	
GOS	Postoperative	3.94	0.347	

Abbreviations: GOS, Glasgow Outcome Score; KPS, Karnofsky Performance Scale.

patients underwent optic foramen deroofing. One patient had severely thinned out optic nerve and had visual deterioration. Additionally, five TSM required extradural clinoidectomy to aide decompression of the optic nerves. One among them, had transient CSF leak and was managed with lumbar drain. One patient expired due to the malignant infarct of ACA and MCA territory and raised intracranial pressure.

Discussion

There have been many approaches described for the management of AMSBM.

Bifrontal Craniotomy and Uni/Bifrontal Approach^{17–20}

Advantages

1. Wide exposure.
2. Ease of drilling.
3. Unilateral subfrontal approach can expose bilateral optic nerves at the same time.

Concerns

1. Risk of CSF leak and meningitis following an exposed frontal sinus.
2. Superior sagittal sinus ligation.
3. Bilateral frontal lobe retraction.

Transbasal Approach^{20–22}

Advantages

1. Good exposure to paranasal sinuses
2. Permits early devascularization

Concerns: Large defect and CSF leak

Pterional Approach^{11,23–25}

Advantages

1. Early identification and preservation of the neurovascular structures.
2. Avoidance of inadvertent frontal sinus exposure and thereby CSF leak.
3. Early CSF release prior to tumor manipulation.
4. Potential preservation of olfaction.
5. Shortest distance to sella-parasellar region.
6. Avoidance of sinus ligation.
7. Unilateral frontal lobe retraction.

Concerns

1. Difficult access to the contralateral side in case of large tumors.
2. Difficult access to ipsilateral optic canal and inferior surface of chiasm.

Lynch et al proposed that lateral tilt of the operating table combined with medialization of the microscope can be used to overcome this problem.

Supraorbital Keyhole Approach^{18,26}

Advantages

1. Aesthetic incision and scar.
2. Less frontal lobe injury and CSF leak.

Concerns

1. Spatial limitation, especially in large tumors.
2. Anatomic orientation and learning curve.

Endoscopic Endonasal Approach²⁷

Advantages

1. No brain retraction.
2. Early devascularization.
3. Bilateral medial optic nerve decompression.

Concerns

1. High rates of CSF leak
2. Tumors with lateral extension are difficult to access

With the above knowledge, we propose unilateral pterional craniotomy for excising these lesions with similar outcomes and lesser complications.

Our study population had female ($n = 45$) predominance. Owing to anatomical location, pliability, and relation to eloquent regions, OGMs tend to grow into large sizes before being clinically evident. Almost 40% of tumors were more than 40 mm in size. Optic apparatus being the closest important structure to tuberculum sella and planum sphenoidale, visual disturbances were the predominant symptom with similar findings in our study population.

Patients underwent pterional approach, preferably from the nondominant side,²⁸ but based on lateralization of tumor mass, optic canal extension, and vascular involvement on to the left side, the tumor was approached through the left side.²⁹ Patients with severe optic canal compression underwent deroofing of the optic canal and, anterior clinoidectomy was done to increase accessibility when required. The utility of optic foramen decompression mirrored in our results in which six patients (60%) had visual improvement on post-operative follow-up.

A study by Lynch et al¹¹ also reported good outcomes with unilateral pterional craniotomy, with complete excision and visual improvements of 86 and 89%, respectively, while these were 94 and 67%, respectively, in our group. CSF leak was significantly lower (1.6%) in our study compared to 5.2% in the former study.

With the pterional approach, we attained 94% complete excision. The same was 89% with OGMs. When compared with bifrontal craniotomy, it was 84 to 94%.^{18,20} Another meta-analysis by Feng et al observed 94.6% of complete excision.¹⁹ But Sughrue et al and Hasseleid et al showed that Simpson grade has negligible relevance in prognostication of skull base meningiomas.^{30,31} There are different consensus regarding the management of bony thickening or infiltration. Some prefer to manage conservatively, coagulate dura, and superficial removal of hyperostotic bone,^{9,32}

while others advocate complete drilling and repair of the defect.^{33,34} We recommend complete excision, drilling and repair with fat and pericranial fascia.

Among patients with OGMs, significant postoperative edema was seen in 15% cases. This was 17.1% with bifrontal approaches and 19% with pterional approach in a series by Pallini et al.²⁰ Four patients (20%) had new-onset postoperative seizures, which were significantly higher when compared with pooled data from Feng et al (1.8%), Pallini et al (4.8%), and Lynch et al (7.8%). This can be attributed to the marginally increased incidence of brain contusions in our series. Visual improvement was seen in 71% of patients, which is comparable with the pooled estimates from bifrontal approaches, that is, 70%. There was no postoperative CSF leak and meningitis in our series, whereas it was 6.3 and 1.2%, respectively, with bilateral approaches.¹⁹ Owing to the short follow-up period, there was no recurrence in the present series. New onset anosmia in this series (10%) is comparable with bifrontal approaches (7.5%). The mortality rate was less (3.3%) compared to bifrontal approaches reaching 5.7% in the Pallini et al series and pooled data from Feng et al.^{19,20}

The focus completely shifts onto the visual disturbances in the management of planum sphenoidale and TSM. Among the 34 patients with visual disturbances, 23 (67%) patients had improvements postoperatively. Larger series by Schick and Hassler demonstrate similar outcomes of 50 to 66% improvement.³⁵ Different mechanisms are involved in the pathogenesis of visual impairment. Tumor causing mechanical compression over the optic nerves, perforator occlusion leading to demyelination and direct tumor invasion.³⁶ In our series, 10 patients underwent optic canal deroofing and 6 patients (60%) had improvement in vision. Leclerc et al³⁷ recently showed 60% visual improvement while addressing the predictive factors of favorable outcomes. They observed that symptom duration of fewer than 6 months, preserved visual acuity, T2 high signal intensity, soft tumor, and clear brain-tumor interface were associated with good outcomes. Pulmonary thromboembolism was a nonspecific complication seen in all approaches.^{5,12,19,38} One patient with PSM expired due to pulmonary thromboembolism in our series. Only two patients (10%) with PSM had a recurrence; this could be partially attributable to the relatively shorter follow-up period.

Recently, transsphenoidal endoscopic approaches have gained popularity in tackling these lesions owing to the ability to decompress optic nerves and devascularize tumors early in the procedure, extracapsular removal, and minimal or no handling of neurovascular structures. But still this approach needs further evaluation and improvements as it is limited by CSF leak rates and meningitis.

Conclusion

There is still confusion regarding optimal management strategy and approach in the treatment of ASBM. Unilateral pterional craniotomy can be used as a standardized approach for the management of these lesions. Large size lesions can be managed via this approach with comparable. Ability of early

CSF drainage gives adequate brain relaxation and less retraction related edema and venous infarct. Early visualization of posterior neurovascular structures gives adequate control and allows careful dissection.

Authors' Contributions

All authors have equally participated in the compilation of this article.

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None.

Conflict of Interest

None declared.

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