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Is Unilateral Extended Pterional Craniotomy Adequate Instead of Bicoronal (Bifrontal) Craniotomy in Large or Giant Olfactory Groove Meningiomas?

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ABSTRACT

AIM: To evaluate the radiological characteristics, clinical features,and surgical outcomes of bicoronal incision and bifrontal craniotomy for olfactory groove meningiomas (OGMs).

MATERIAL and METHODS: This was a retrospective review of 16 patients (nine male and seven female) with large and giant OGMs operated through unilateral extended pterional craniotomy between 2010 and 2022. The radiological characteristics, clinical features,and surgical outcomes were examined.

RESULTS: All patients underwent surgical resection via a unilateral extended pterional approach.The mean age of patients was 62.1 years. The most common presenting symptoms were altered consciousness, seizures, headache,and anosmia. Ten (62.5%) and 6 (37.5%) patients had large (4–6 cm) and giant (>6 cm) OGMs, respectively. The mean tumor diameter was 6.3 cm (range:4–9). Simpson Grade2 resection was achieved in all 16 patients.

CONCLUSION: Unilateral extended pterional craniotomy offers a safe and effective alternative to the bilateral coronal approach for large and giant OGMs, minimizing risks of frontal lobe retraction, brain edema, and venous infarction. This approach allows for total resection with very low morbidity and mortality rates, making it a viable surgical approach for these complex tumors.

KEYWORDS: Giant, Meningioma, Olfactory groove, Pterional craniotomy

INTRODUCTION

Olfactory groove meningiomas (OGMs) are slow-growing tumors originating from the cribriform plate and frontosphenoidal suture, gradually compressing both frontal lobes. As these tumors expand, they may suddenly cause symptoms due to compression of the surrounding neurovascular structures, depending on their size and location. Common presenting symptoms include anosmia, visual disturbances, mental disorders, headaches, and, seizures (11,16).

Transcranial approaches for treating OGMs include bicoronal, unilateral frontal, pterional, and endoscopic endonasal techniques, which can be done separately or in conjunction with microsurgical methods. Given that these tumors are typically located bilaterally in the anterior cranial fossa, bifrontal craniotomy has traditionally been the standard surgical intervention. However, due to the significant disadvantages of this method, unilateral approaches have recently emerged as the preferred alternative for the surgical management of large and giant OGMs (3,4,13).

The aim of this study was to examine the technical nuances and outcomes associated with the unilateral extended pterional approach in the surgical treatment of large and giant OGMs.

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MATERIAL and METHODS

This study has been approved by the ethics committee of University of Health Sciences Izmir Faculty of Medicine, Izmir Bozyaka Training and Research Hospital (18.10.2023-2023/180). The medical records of 16 patients who underwent surgical resection of large and giant OGMs via the unilateral extended pterional approach between October 2010 and October 2022 were reviewed. OGMs were defined as tumors originating from the cribiform plate and frontosphenoidal suture.The diagnosis of OGM was based on clinical history, physical examination, imaging findings, and histopathological examination of the tumor specimens.

All 16 patients included in this study had large or giant OGMs. Tumors with a diameter of 4–6 cm were classified as large, while those larger than 6 cm were defined as giant OGMs. Data pertaining to the following variables were retrieved: age, sex, presenting symptoms, motor deficits, preoperative and postoperative Karnofsky Performance Scores (KPSs), tumor size, degree of excision using the Simpson grading system, World Health Organization (WHO) Grade (histopathological type), complications, Glasgow Outcome Scale (GOS) score at discharge, residual tumor, and adjuvant treatments. All patients underwent preoperative head computed tomography (CT) and contrast-enhanced magnetic resonance imaging (MRI) to evaluate tumor size, lateralization, tumor spread, involvement of surrounding neurovascular structures, and edema. CT was performed in the early postoperative period. Follow-up MRI examinations were conducted at 3 months and 1 year. The amount of resection was evaluated using postoperative MRI scans according to the Simpson grading system.

Unilateral Extended Pterional Approach

The patient is intubated under general anesthesia and positioned supine with the head of the bed elevated at 20°. The patient's head is secured to the Mayfield three-point head holder (Integra Life Sciences, Billerica, MA) after being rotated 30° laterally to allow exposure of the tumor. A right-sided frontobasal extended pterional craniotomy is performed unless the tumor extends significantly to the left side. The special feature of this surgical technique is a pterional craniotomy extending into the frontal bone, providing subfrontal access in addition to the usual anterolateral view provided by the classic pterional approach. The craniotomy extends from the frontal bone to the ipsilateral supraorbital process, avoiding the frontal sinus. The lesser wing of the sphenoid bone and the base of the orbit are drilled using a high-speed drill and a thin footplate rongeur until the complete exposure of the meningo-orbital band. The frontal craniotomy is extended to the midline and superior orbital rim using a drill. The dura is opened in a C-shape, and proximal sylvian dissection is performed. The opticocarotid cistern is opened to allow cerebrospinal fluid (CSF) outflow and brain relaxation. The arachnoid membrane around the tumor is dissected. Following devascularization and internal debulking, the tumor is ready to be dissected from the circumambient tissue. The lesion is excised in a piecemeal fashion using a combination of ultrasonic aspiration, bipolar cautery, and suction. Then, the ipsilateral optic nerve and internal carotid artery (ICA) are exposed. The ICA is dissected distally to reveal the middle cerebral artery and the A1 and A2 branches of the anterior cerebral artery. It is crucial to identify and dissect both A2s, which form a C-shape around the tumor, before starting excision from the tumor capsule. After identifying both A2s and adequate debulking, the corridor between the tumor tissue and parenchyma is meticulously dissected using cotton pads.This allows for the tumor to be gently displaced forward and downward. It is crucial to identify and preserve the olfactory tract during tumor resection. The falx is incised, and the tumor tissue on the contralateral side is accessed and excised while staying in the arachnoid plane. The base of the tumor and the capsule bilaterally adherent to A2 are resected, and the tumor feeders are coagulated. The basal dura invaded by the tumor is coagulated with bipolar electrocautery. Finally, the hypertrophic bone adherent to the dura is carefully drilled away without entering the sphenoidal sinus.

Statistical Analysis

All statistical analyses were conducted using the Statistical Package for the Social Sciences, version 22.0. Continuous variables were expressed as mean values.

RESULTS

This study included 16 patients [nine (56.2%) female and seven (43.8%) female] with large or giant OGMs who underwent tumor resection via unilateral extended pterional approach by the senior surgeon (A.Y.). The mean age of the patients was 62.1 years (range: 46–81). The most common presenting complaints were altered consciousness (6 patients; 37.5%), seizures (5 patients; 31.2%), headache (2 patients; 12.5%), and anosmia (2 patients; 12.5%). Other less frequent symptoms were diplopia, blurred vision, syncope, and ataxia. Anosmia was a less common finding because altered consciousness and seizures are more common in patients with such large tumors. Moreover, anosmia could not be evaluated in patients presenting with altered consciousness and seizure.The mean diameter of OGMs in this series was 6.3 cm (range, 4–9 cm). There were ten patients (62.5%) with large (4–6 cm) OGMs and 6 (37.5%) patients with giant (>6 cm) OGMs (Table I). Edema was detected in all 16 patients on preoperative fluid-attenuated inversion recovery (FLAIR) MR images. Furthermore, vascular encirclement was observed in ten patients (62.5%). Right extended pterional craniotomy was performed in 14 out of 16 patients (87.5%). In the remaining two patients (12.5%), the tumor had extended significantly to the left side; therefore, left frontobasal extended pterional craniotomy, which did not cross the midline, was performed.

The frontal sinus was opened in three patients (18.7%) during the operation, and in all three cases, it was filled and repaired with subcutaneous fascia and fibrin sealant (Tisseel). None of these three patients developed intracranial infection. CSF leakage occurred in one patient, which resolved spontaneously.

The mean preoperative and postoperative KPSs in this series were 66.2 (range:40–90) and 75.6 (range:60–90), respectively. Simpson Grade 2 resection was achieved in all 16 patients (macroscopically gross total resection and coagulation of the dural connection were performed) (Figures 1-3).

Table I: Demographic Characteristics, Imaging Findings, Pathological Types, and Survival of Patients with a Diagnosis of Large or Giant Olfactory Groove Meningioma

Patient No	Age/ Sex	Presenting symptom	Tumor Size in Diameter (mm)	Histopathology	Simpson Resection Grade	KPS (Pre- and Post-operative)
1	73/M	Mental disturbances	50	Meningothelial meningioma, WHO Grade 1	Grade 2	50-90
2	57/F	Seizure	60	Meningothelial meningioma, WHO Grade 1	Grade 2	40-90
3	46/M	Headache, weight gain	70	Chordoid meningioma, WHO Grade 2	Grade 2	60-70
4	56/M	Anosmia, Mental disturbances	60	Atypical meningioma, WHO Grade 2	Grade 2	80-70
5	50/M	Mental disturbances	50	Chordoid meningioma, WHO Grade 2	Grade 2	60-80
6	73/F	Mental and visual disturbances	80	Angiomatous meningioma, WHO Grade 1	Grade 2	70-70
7	51/M	Anosmia, Mental disturbances	70	Atypical meningioma, WHO Grade 2	Grade 2	60-70
8	57/ F	Seizure	80	Anaplastic meningioma, WHO Grade 3	Grade 2	80-70
9	62/ F	Diplopia, blurred vision	60	Angiomatous meningioma, WHO Grade 1	Grade 2	90-90
10	68/ F	Seizure, Mental disturbances	40	Anaplastic meningioma, WHO Grade 3	Grade 2	80-80
11	81/M	Mental disturbances	70	Transitional meningioma, WHO Grade 1	Grade 2	50-60
12	76/M	Headache, diplopia	60	Angiomatous meningioma, WHO Grade 1	Grade 2	80-80
13	52/M	Seizure	90	Transitional meningioma, WHO Grade 1	Grade 2	90-90
14	60/ M	Seizure	60	Angiomatous meningioma, WHO Grade 1	Grade 2	50-60
15	61/ F	Mental disturbances	50	Transitional meningioma, WHO Grade 1	Grade 2	70-80
16	72/ F	Mental disturbances	60	Atypical meningioma, grade 2	Grade 2	50-60

WHO: *World Health Organizaton,* ***KPS:*** *Karnofsky Performance Score,* ***mm:*** *millimeters.*

Histopathological evaluation revealed WHO Grade I (meningothelial, transitional, angiomatous) in 9 (56.2%) patients, WHO Grade 2 (atypical and chordoid) in 5 (31.2%) patients, and WHO Grade 3 (anaplastic) in 2 (12.5%) patients (Table I). The mean cell proliferation index (Ki-67) was 3.8%.

Regarding postoperative complications, CSF leakage occurred in one patient, infarction in the anterior cerebral artery territory occurred in one patient, spontaneously resorbed hemorrhage in the operation cavity occurred in one patient, and dipolopia was observed in two of the patients. Despite preserving the olfactory nerve, there was no improvement in the sense of smell in patients with anosmia, whereas all patients with vision defects showed significant improvement in the visual field test. There was no operative mortality in our series, and all patients were discharged without additional neurodeficit. The neurological status of the patients was evaluated using the GOS score at discharge. Ten patients (62.5%) were discharged with GOS 5 (good recovery), 4 (25.0%) were discharged with GOS 4 (moderate disability), and 2 (12.5%) were discharged with GOS 3 (severe disability) (Table II).

Table II: Complications and the Glasgow Outcome Scale Score

Complication	n (%)
Diplopia	2 (12.5)
CSF leak	1 (6.2)
Arterial infarction	1 (6.2)
Hematoma in the operating cavity	1 (6.2)
Glasgow Outcome Scale Score	
5	10 (62.5)
4	4 (25.0)
3	2 (12.5)

GOS: *Glasgow Outcome Score.*

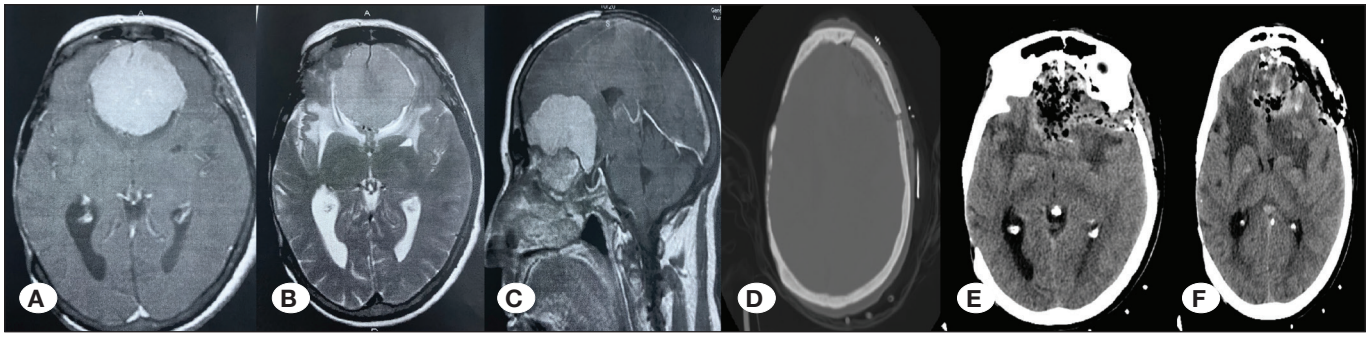

Figure 1: Preoperative cranial MRI showing a large olfactory groove meningioma (**A:** T1-weighted axial image with contrast enhancement, **B:** T2-weighted axial image, **C:** T1-weighted sagittal image with contrast enhancement). **D)** Craniotomy borders are visible on axial computed tomography axial CT scans. **E-F)** Postoperative CT confirming total excision of the mass lesion.

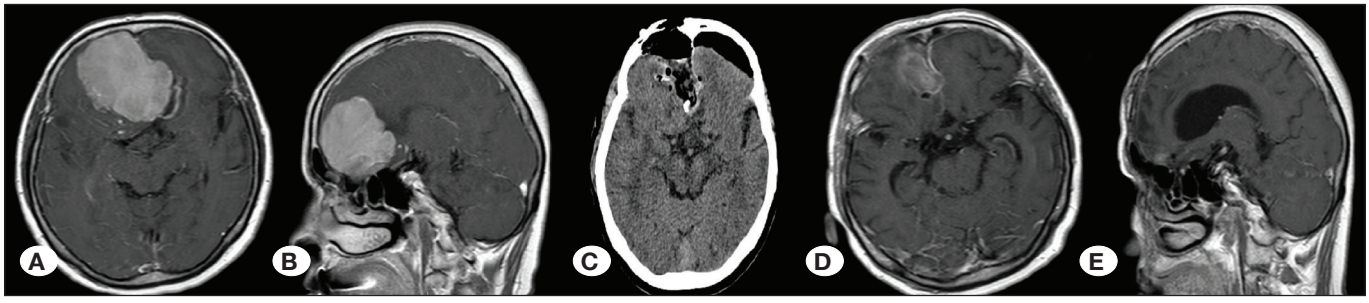

Figure 2: Preoperative axial **(A)** and sagittal **(B)** contrast-enhanced T1-weighted MR images show a giant olfactory groove meningioma. **C)** Postoperative axial computed tomography scan showing total excision of the mass lesion. **D, E)** Postoperative 3-month follow-up cranial MRI scans confirming total excision of the mass lesion.

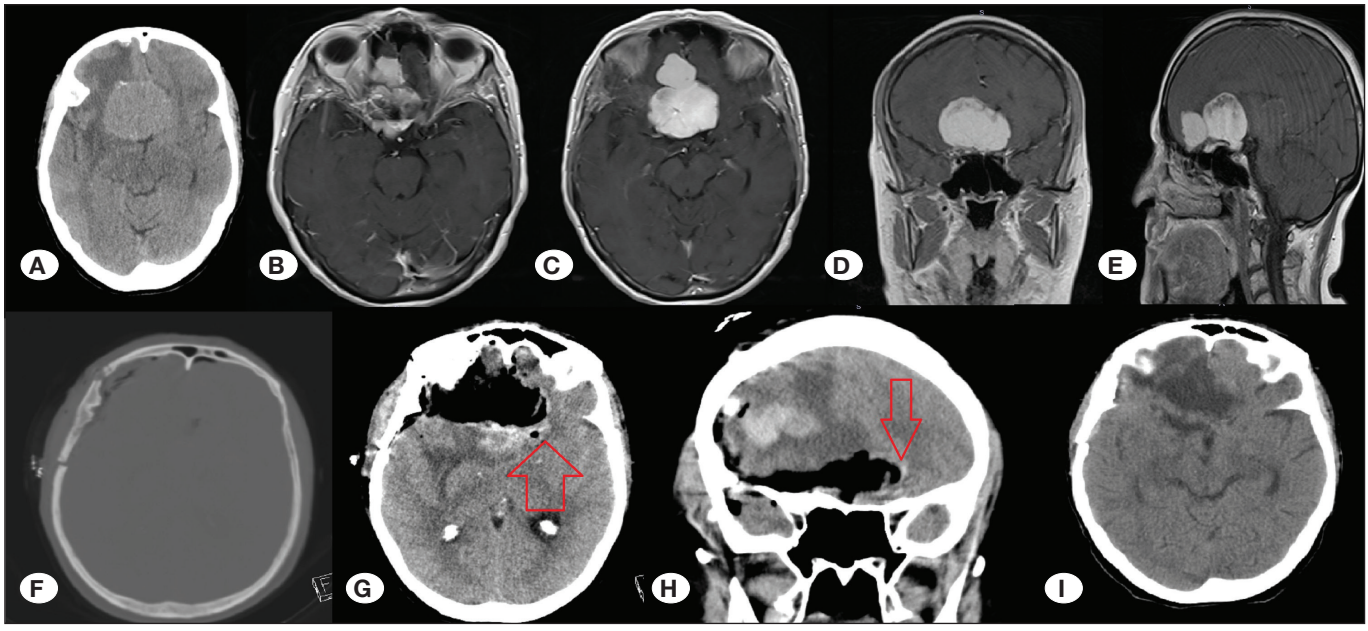

Figure 3: Preoperative axial computed tomography (CT) **(A)** and axial **(B, C)**, coronal **(D)**, and sagittal **(E)** contrast-enhanced T1-weighted MR sequence imagings showing a large olfactory groove meningioma. Craniotomy borders are visible on CT scan **(F)**. Postoperative CT images **(G, H)** confirming total excision of the mass (the red arrows show the area reaching the opposite side with a unilateral extended pterional approach). **I)** Postoperative 3-month follow-up cranial CT scan confirming total excision of the mass lesion.

All patients were followed up clinically for 2 years (range: 1 month to 3 years). Tumor recurrence/progression was observed in 2 (12.5%) patients (both with a pathological diagnosis of anaplastic meningioma). These patients were treated with adjuvant Gamma Knife radiosurgery. There was no recurrence in the five patients with WHO Grade 2 (atypical and chordoid) meningiomas.

DISCUSSION

OGMs account for approximately 9%–12% of intracranial tumors, typically originating from the midline, the ethmoidal cribriform plate, and occasionally extending into the ethmoidal sinuses (15% of cases). Rarely, they may invade the nasal region and orbit (1). The primary blood supply is via the anterior and posterior ethmoidal arteries, the meningeal branches of the ophthalmic artery. When the tumor reaches a large size, it may receive blood supply from the anterior cerebral artery and the anterior communicating artery (1). Meningiomas originating from the olfactory groove characteristically displace the optic nerve and chiasm downward and posteriorly. Owing to their close proximity to vital neural and vascular structures, there is no clear consensus on the optimal surgical approaches for these lesions (7,8,10). Although all patients in ourseries had largeor giant OGMs, gross total resection (Simpson Grade 2) was achieved in all patients because the arachnoid plane between the tumor and neurovascular structures was intact.

Despite the development of various surgical approaches for OGMs, a consensus on the optimal approach remains elusive (9). Since each approach has advantages and disadvantages, a tailored case-specific surgical approach is recommended. Several studies have reported that pterional and minipterional approaches are generally sufficient for small OGMs sized<4 cm. However, there is a paucity of reports on the outcomes of unilateral pterional approaches for large (4–6 cm) and giant (>6 cm) OGMs (6). The major limitations of unilateral approaches are the limited surgical corridor and access to the entire tumor, particularly on the contralateral side, which remains distant from the surgeon's view. Extreme manipulation of the frontal lobes may be required to visualize the tumor. In cases where total excision is the goal, especially for larger tumors, the prevailing opinion among neurosurgeons is to perform a bicoronal craniotomy and to create a wider working corridor by ligating the superior sagittal sinus (12,15). Our study indicates that the extended pterional approach can be used for the total excision of large and giant OGMs without causing additional morbidity and mortality. Extended pterional craniotomy, which is the subject of our study, has some advantages over other procedures (bicoronal craniotomy). The most important advantage of the unilateral extended approach isthe preservation of the venous outflow of the unused hemisphere, namely the left one in most cases. It provides the shortest distance to the anterior skull base, minimizes frontal lobe retraction, and allows early drainage of CSF from the basal cisterns. The other advantages of this approach include the wide opening of the Sylvian fissure to expose the frontal and temporal lobes, avoiding entry into the frontal sinus, and protecting the superior sagittal sinus. Early exposure of the optic nerve and chiasm using this approach allows preservation of the visual pathway. Furthermore, early identification of the ICA and convenient dissection of the anterior cerebral artery and its branches allow the preservation of these vessels. Additionally, it allows easy identification and preservation of the olfactory pathway after resection of most of the tumor by debulking. None of the patients in our series sustained any injury to large vessels, optic nerve, or olfactory nerve. On long-term follow-up, no improvement was observed in olfactory sensation, but a significant improvement was observed in visual acuity.

CSF leakage is a serious postoperative complication after resection of anterior skull base tumors, especially giant OGMs (2,5,14). In our series, CSF leakage was detected in one patient, which was stopped with conservative treatment consisting of bed rest, diazomide treatment, fluid restriction, and lumbar puncture twice daily. Although peritumoral edema is almost always observed in large or giant tumors located in the anterior cranial fossa, infarction may develop and neurodeficit may be observed due to the sacrifice of venous structures or the failure to preserve feeders during surgery. In one patient, although vascular structures were preserved during surgery, transient postoperative neurodeficit developed in the anterior cerebral artery territory. In our series, two patients with anaplastic meningioma pathology had tumor recurrence that was treated by Gamma Knife radiosurgery.

Limitations

Some limitations of this study should be acknowledged. Since this was a retrospective cohort study, we could not compare the extended pterional approach with other approaches. The small sample size is another limitation. For rare complications, such as infarction and visual deficits, a limited cohort size may not reflect their true incidence.

CONCLUSION

The unilateral external pterional approach is safe and effective for treating large and giant OGMs. This approach enables total excision of the mass with minimal morbidity and no mortality while avoiding the disadvantages of classical bifrontal craniotomy, such as the risk of venous injury, superior sagittal sinus injury, infection, and CSF leakage. The extended pterional approach provides two important advantages: early neurovascular control and minimal morbidity and mortality due to limited frontal lobe retraction.

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Declarations

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Availability of data and materials: The datasets generated and/or analyzed during the current study are available from the corresponding author by reasonable request.

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AUTHORSHIP CONTRIBUTION

Study conception and design: HY, EA, HBB, AT, OB, AY
Data collection: HY, AT, HBB
Analysis and interpretation of results: HBB
Draft manuscript preparation: CA, HY
Critical revision of the article: HY
Other (study supervision, fundings, materials, etc...): HY, EA, AT, OB, CA, HBB, AY
All authors (HY, EA, AT, OB, CA, HBB, AY) reviewed the results and approved the final version of the manuscript.

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