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Topographic Patterns of Recurrence of Olfactory Groove Meningiomas After Transcranial Approach

Francesco Maiuri, Jacopo Berardinelli, Giuseppe Corazzelli, Federico Russo, Sergio Corvino

■ BACKGROUND: **Olfactory groove meningiomas may recur up to 30% of cases. This study focused on the topographic patterns and location of the recurrences and their surgical management.**

■ METHODS: **Data on topography of recurrences from a single-center surgical series of olfactory groove meningiomas were retrospectively reviewed and analyzed along with data from pertinent literature. Analyzed factors included patient age and sex; extent of resection and management of infiltrating dura and skull base at initial surgery; time to recurrence; clinical presentation at recurrence; size, location, and histology of recurrent tumors; and management of recurrent tumors.**

■ RESULTS: **Overall sample included 33 patients, 4 from our series and 29 from the literature. The main reported symptoms at recurrence were visual function deterioration (67%), nasal obstruction (41%), and headache (40%). The recurrent tumor involved the skull base in all cases (100%). Intracranial regrowth and sinus invasion were observed in 84% of cases. Surgery was performed mainly through the same transcranial approach (76%) or combined transcranial-transnasal approach (17%). Although Simpson grade I resection was possible in more than half of patients, a residual intradural tumor (Simpson grade IV) was left in one third.**

■ CONCLUSIONS: **Recurrences of olfactory groove meningiomas treated by transcranial approach mainly occur at the cranial base, bone, paranasal sinuses, and optic canals. This suggests resecting at the initial surgery the involved dura and bone to decompress the optic pathways. Reoperation should attempt gross total resection, at least in cases with more limited bone invasion.**

INTRODUCTION

Olfactory groove meningiomas (OGMs) account for 8%–14% of all intracranial meningiomas.[1] They arise from the arachnoid cap cells located at the ethmoid cribriform plate and the sphenoidal suture,[1,2] and their pattern of growth shows a tendency to infiltrate the olfactory nerves and the ethmoid bone as well as to displace or envelope the anterior cerebral arteries.[3] Therefore, the main presenting symptom is hyposmia/anosmia, which also is a key factor in selecting the surgical approach.

Surgery is the gold standard treatment for growing or symptomatic tumors, with the goal of achieving gross total resection, including the invaded dura and bone (Simpson grade I[4]), while preserving neurocognitive functions.[5] Nevertheless, even after Simpson grade I resection, the recurrence rate ranges from 0%[6] to 30%.[7,8] These differences depend on several factors, including tumor size and extension at the initial diagnosis, extent of the resection, management of the dural attachment and basal bone at initial surgery, and length of the follow-up. Many studies of OGMs treated via transcranial approaches have examined the anatomical relationship of the tumor with surrounding bone and neurovascular structures, including basal bone, paranasal sinuses, optic canals and nerves, olfactory nerves, and pericallosal arteries, as well as the clinical and surgical implications.[1,2,6,9-17] On the other hand, the topographic patterns and locations of the recurrences have been scarcely investigated.

Key words
- Endoscopic endonasal approach
- Meningiomas
- Olfactory groove
- Recurrence
- Skull base

Abbreviations and Acronyms
CSF: Cerebrospinal fluid
OGM: Olfactory Groove Meningioma

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MATERIALS AND METHODS

Medical record data from a single-institution neurosurgical series of 60 patients who underwent microsurgical transcranial resection of OGMs at the Neurosurgical Clinic of the University of Naples Federico II between 1995 and 2018 were reviewed to identify recurrent tumors. Only cases with a primary, nonrecurrent tumor with dural attachment at the olfactory groove and lamina cribrosa, as confirmed by contrast-enhanced magnetic resonance imaging of the brain, were included. Of 60 patients, 4 (6.7%) experienced tumor recurrence during follow-up (ranging from 40 months to 20 years).

In addition, a literature review was conducted from January 2000 to June 2023 using PubMed and Ovid Embase online electronic databases, according to the PRISMA[18] guidelines, and to analyze OGM recurrences. The following search terms were used: olfactory groove meningioma recurrences, anterior skull base meningioma recurrences, and anterior cranial fossa meningioma recurrences. Surgical series, reviews, and case reports published in English as well as studies in other languages but including the abstract in English were included. Only studies that reported the topographic pattern of the recurrences of OGMs have been included. The analyzed factors included patient sex and age, extent of resection (Simpson grade[4]), management of dural attachment and basal bone at the initial diagnosis, time to recurrence, clinical presentation at recurrence, size of recurrent tumor, topographic patterns of the recurrence (intracranial, cranial base, or sinus invasion), management of the recurrence, histological World Health Organization grade, and outcome.

RESULTS

The inclusion criteria were met by 4 of 60 patients from our surgical series and 29 patients from 6 studies[4,6,11,12,19,20] (of 38 from the literature review), for an overall series of 33 cases. Data from our 4 patients who experienced tumor recurrence are summarized in Tables 1 and 2. The extent of tumor resection at the initial surgery was Simpson grade II in 2 cases and grade III in the other 2 cases. Three patients had focal infiltration of the skull base and tumor invasion of the paranasal sinuses, and 2 patients also had extension to 1 or both optic canals. Tumor adherence to the pericallosal arteries with loss of the arachnoid interface was observed in 1 case.

The recurrent meningiomas were located in the ethmoid bone and paranasal sinuses in all 4 cases (Table 2), whereas extension into the nasal cavities was recorded in 3 cases. Intracranial regrowth occurred in the basal region in 3 cases, in the optic canals in 2 cases, and at the falx cerebri in 1 case. Reoperation was performed through a transcranial subfrontal approach in 1 case and combined subfrontal/transnasal approach in 2 cases (1 patient refused surgery). All patients underwent adjuvant radiotherapy with 60 Gy to the surgical field.

Regarding outcome, 1 patient died due to tumor progression 8 years after reoperation. One patient experienced progression and refused a transsphenoidal operation. The last 2 patients are alive with no further recurrence.

Data of the 33 patients (including ours) with reported topographic patterns of recurrence after transcranial surgery are summarized in Table 3. The majority of patients were women (67% vs. 33%) with an age range of 19–76 years (median age 52 years).

Data on the initial surgery are available for only 21 patients. Gross total resection (Simpson grades I–III) was achieved in all but 1 case; however, most patients underwent grade II resection, with coagulation of the dura mater, whereas resection of the dural attachment was performed in only 4 patients (9%). The basal bone was resected in just 5 cases (24.6%), despite being mostly infiltrated.

The time to recurrence ranged from 1.5 to 10 years (median 4.8 years). The clinical presentation at recurrence, available in 24 cases, was highly variable. Deterioration of visual function occurred in 16 patients (67%) due to tumor extension to the optic canals and/or compression of the optic pathways. Symptoms of nasal obstruction were reported by 10 patients (41%) with tumor extension in the paranasal sinuses and/or nasal cavities. Headache was also frequent. Other symptoms were less common. Regarding tumor size, most recurrent tumors (81%) had a maximum diameter $\geq$3 cm.

The analysis of tumor regrowth patterns and recurrence location revealed interesting findings. Tumor extension to the cranial base bone, ranging from small tumor nodules within ethmoidal cells to areas of large bone invasion, was evident in all 33 reviewed cases (100%). Invasion of paranasal sinuses was present in 27 of 32

Table 1. Surgical Features of the 4 Recurrent Cases at Initial Surgery

Covariates	Case 1	Case 2	Case 3	Case 4
Surgical approach	Pterional	Subfrontal unilateral	Subfrontal unilateral	Subfrontal bilateral
Extent of resection (Simpson grade)	III	II	II	III
Hyperostosis of crista galli	–	–	+	–
Focal infiltration of skull base	+	+	–	+
Paranasal sinus invasion	+	+	–	+
Optic canal invasion	+	–	–	+
Encasement of the anterior cerebral arteries	–	–	–	+

+, present; –, not present.

Table 2. Location, Management, and Outcome of the Recurrences

Covariates	Case 1	Case 2	Case 3	Case 4
Location of recurrence				
Basal bone	+	+	+	+
Paranasal sinuses	+	+	+	+
Nasal cavities	+	−	+	+
Intracranial	+ (basal, optic canal)	+(basal)	−	+ (basal optic canal)
Surgical approach	Combined subfrontal transnasal	Subfrontal	Combined subfrontal transnasal	Refused surgery
Extent of resection (Simpson grade)	I	III	I	III
Outcome	Dead 8 years after operation due to tumor progression	No recurrence, alive	No recurrence, alive	Tumor progression, alive

+, present; −, not present.

patients (84%). The ethmoidal sinus was almost always involved (92%), followed by the sphenoid sinus (60%). Invasion of the nasal cavities was observed in 7 patients (26%). Intracranial recurrent tumor was identified in 21 of 27 patients with available data (84%). The most frequent intracranial recurrence site was the anterior cranial fossa (71%); nearly half of the cases (n = 10; 48%) showed recurrent tumor in 1 or both optic canals and nerves. Regrowth at the falx was rare (9%).

Reoperation was performed in 30 patients with recurrent tumor, whereas 3 were managed conservatively. In most cases (n = 23/30; 76%), the same transcranial approach as the initial surgery was used. A combined transcranial and transfacial approach was used in 5 patients, and only 2 patients were treated by an isolated inferior approach (1 transfacial and 1 endoscopic endonasal). Among the 23 patients with available data, Simpson grade I resection was achieved in 13 cases (57%), whereas a residual intracranial tumor nodule (Simpson grade IV) was found on postoperative imaging in 7 (30%) cases.

Histological data were available for 28 cases, revealing that most tumors (82%) were World Health Organization grade I. follow-up evaluation, reported in 11 patients, 8 remained stable with no regrowth, whereas 3 showed progression or further recurrence.

DISCUSSION

Many well-documented demographic, pathological, radiological, and surgical factors influence the recurrence rate of intracranial meningiomas.[21-32] This study focused on the topographic patterns of recurrences in OGMs following a transcranial approach. Understanding these patterns is crucial for determining the extent of surgical resection needed during the initial surgery to prevent or reduce the recurrence rate. Our review highlights that cranial base invasion is present in all recurrent OGMs, whereas intracranial recurrence and invasion of the paranasal sinuses occur in 84% of cases. Notably, no cases of isolated intracranial regrowth in the absence of cranial base invasion have been reported.

The dural attachment of OGMs is usually confined to the crista galli and olfactory groove, but can sometimes extend to the surrounding dural regions. Although coagulation may be sufficient in cases with limited dural attachment to prevent cerebrospinal fluid (CSF) leakage, extensive dural infiltration and dural thickening require resection. This basal extradural approach allows for early coagulation of the ethmoidal arterial feeders, thus obtaining early tumor devascularization. However, it invariably leads to loss of smell and increases the risk of CSF leak through the lamina cribrosa and ethmoidal cells, even in cases without basal bone involvement. Therefore, dural resection is justified in patients with complete anosmia and significant dural infiltration.

Basal bone infiltration is a significant risk factor of recurrence, making its management a crucial aspect of treatment. Although significant bone invasion is evident on preoperative computed tomography scan, smaller and more localized bone infiltrations may go undetected even on high-quality magnetic resonance imaging scans and are identified only during surgical exploration.

Removing the infiltrated basal bone via a transcranial approach is more invasive, leading to anosmia and, in some cases, CSF fistula. However, most patients with obvious tumor infiltration of the anterior cranial fossa are already anosmic before surgery. As a result, radical resection of the infiltrated bone, including extensive ethmoid bone drilling, is mainly indicated in younger patients with preoperative anosmia. Ethmoidal sinus infiltration predisposes to tumor recurrence and requires radical resection.[6,12]

A more conservative approach to basal bone management at initial surgery involves drilling of the hyperostotic bone and limiting resection of an eventual superficial bone infiltration. This approach is justified in older patients with limited and superficial bone invasion for several reasons. First, small intraosseous tumor fragments may remain stable or slowly grow for years, at least for benign World Health Organization grade I meningiomas. Second, the recurrence rate of OGMs is generally low except in cases with marked invasion of the basal bone and ethmoid. Lastly, bony recurrences are more often asymptomatic and do not cause neurological symptoms.

Intracranial recurrences primarily occur in the anterior cranial fossa, with nearly half of the reviewed cases showing recurrent tumor in 1 or both optic canals. Consequently, visual deterioration due to optic compression is the most common symptom of recurrence. Large OGMs and tumors with significant posterior

Table 3. Summary of Data of 33 Patients with Topographic Pattern of Recurrence of Olfactory Groove Meningiomas Treated by Transcranial Approach

Covariates	Number of Patients with Available Data	Results
Patient population		
Sex	33	Female: 22 (67 %)
		Male: 11 (33%)
Age (years)	33	Range: 19—76
		Median: 52
Findings at initial surgery		
Extent of resection (Simpson grade)	21	I: 4 (19%)
		II: 14 (67%)
		III: 2 (9.5%)
		IV: 1 (4.5%)
Management of dura	21	Coagulated: 17 (81%)
		Resected: 4 (9%)
State of basal bone	12	Intact: 4 (33%)
		Infiltrated 8 (67%)
Management of the basal bone	21	Not resected: 16 (76%)
		Resected: 5 (24%)
Time to recurrence (years)	18	Range: 1.5—10
		Median: 4.8
Clinical presentation at recurrence	24	Deterioration of the visual function: 16 (67%)
		Symptoms of nasal obstruction: 10 (41%)
		Headache: 8 (40%)
		Memory loss: 2 (8%)
		Epilepsy: 2 (8%)
		Epistaxis: 1 (4%)
Size of recurrent tumor (maximum diameter) (cm)	16	<3: 3 (19%)
		3—5: 8 (50%)
		>5: 5 (31%)
Topography of recurrences	27	No: 6 (16%)
		Yes: 21 (84%)
		ACF: 15 (71%)
		OCs/ONs: 10 (48%)
		Falx: 2 (9%)
Cranial base	33	33 (100%)
Sinus invasion	32	No: 5 (16%)
		Yes: 27 (84%)
		Ethmoidal: 25 (92%)
		Sphenoid: 16 (60%)
		Frontal: 4 (15%)
		Maxillary: 3 (10%)
		Nasal cavities: 7 (26%)
		Nasopharynx: 1 (3%)
Management of recurrences		
Surgical approach	30*	TCA: 23 (76%)
		Combined: TCA and TFA 5 (17%)
		TFA: 1 (3%)
		EEA: 1 (3%)
Extent of resection (Simpson grade)	23	I: 13 (57%)
		II: 0
		III: 3 (13%)
		IV: 7 (30%)
Histology of recurrent tumor (WHO grade)	28	I: 23 (82%)
		II: 3 (13%)
		III: 2 (7%)
Outcome	11	Regrowth or progress: 3 (27%)
		Stable (no further growth): 8 (73%)

ACF, anterior cranial fossa; OCs, optic canals; ONs, optic nerves; TCA, transcranial approach; TFA, transfacial approach; EEA, endoscopic endonasal approach; WHO, World Health Organization.
*No surgery in 3 patients.

extension may reach 1 or both optic canals. For these tumors, Hassler and Zentner[33] and later Yasargil,[34] proposed a pterional approach, which, in contrast to unilateral and bilateral subfrontal approaches, allows for early CSF release and early control of the optic nerves and anterior cerebral arteries. Therefore, complete resection of the posterior tumor component at the initial surgery is essential to prevent residual tumor in the optic canals.

Meningioma recurrence along the falx cerebri is rare (only 2 among 27 cases [9.6%] in our review) but warrants discussion. The falx originates by reflection of the meningeal layers derived from the neural crest at the midline, forming 2 dural leaflets. Tumor nodules may spread along the falx between these layers.[35] Therefore,

resection of the involved falx should extend at least 1–2 cm beyond the tumor margins while preserving the superior sagittal sinus.

In this review, two thirds of the patients underwent reoperation for recurrence via a transcranial approach. However, all these cases were treated before the introduction and widespread adoption of the endoscopic endonasal approach for selected OGMs.[3,36-40] The endoscopic endonasal approach has now almost completely replaced transfacial approaches for recurrent OGMs requiring inferior access.

OGMs tend to recur inferiorly and posteriorly to the original tumor. Therefore, the choice of surgical approach should be based on the location, direction, and growth pattern of the recurrence. The reviewed studies describe various surgical approaches, including bilateral or unilateral subfrontal,[11,19] lateral supraorbital,[6,11,12] subcranial,[20] and pterional[11] techniques. These same approaches were also used for the recurrence. However, the pterional approach is not ideal for recurrent meningiomas with significant anterior skull base infiltration or extension in the ethmoid, as frontobasal bone repair is challenging without significant frontal lobe retraction.[11] For recurrent tumors in the basal bone, a median subfrontal approach is more advisable. A combined transcranial-endonasal approach or, in rare cases, an exclusive endonasal approach is suitable for recurrences diffusively involving the paranasal sinuses and nasal cavities.[41]

A more radical safe resection is the aim of reoperation at recurrence. The most critical surgical step is tumor resection at the optic canals, if involved, and the decompression of the optic nerves and chiasm, given the high rate of visual deterioration. Optic canal decompression can be performed via both transcranial and endoscopic endonasal approaches.

Intracranial recurrences are more often treated with gross total resection. However, cases with more extensive invasion of the basal bone and paranasal sinuses precludes complete resection. In these cases, more or less aggressive surgical resection must be balanced against patient age, challenges in cranial base reconstruction and the risk of postoperative complications. Postoperative radiotherapy is mandatory in recurrent meningiomas, if it was not administered after the initial surgery.

Study Limitations

The main limitations of this study are the retrospective nature of the study, small size of the sample of patients included, and limited availability of data.

CONCLUSIONS

Recurrences of OGMs treated by the transcranial approach mainly occur inferiorly at the cranial base and paranasal sinuses and posteriorly at the optic canals and nerves (Figure 1). This suggests resecting at the initial surgery the involved dura and bone to decompress the optic pathways. Reoperation for the recurrence may be performed by the transcranial, combined transcranial-endoscopic endonasal, or isolated endoscopic endonasal approach, according to the topographic pattern of the tumor regrowth. Although gross total resection is the aim of surgery in cases with more limited bone invasion, a more aggressive

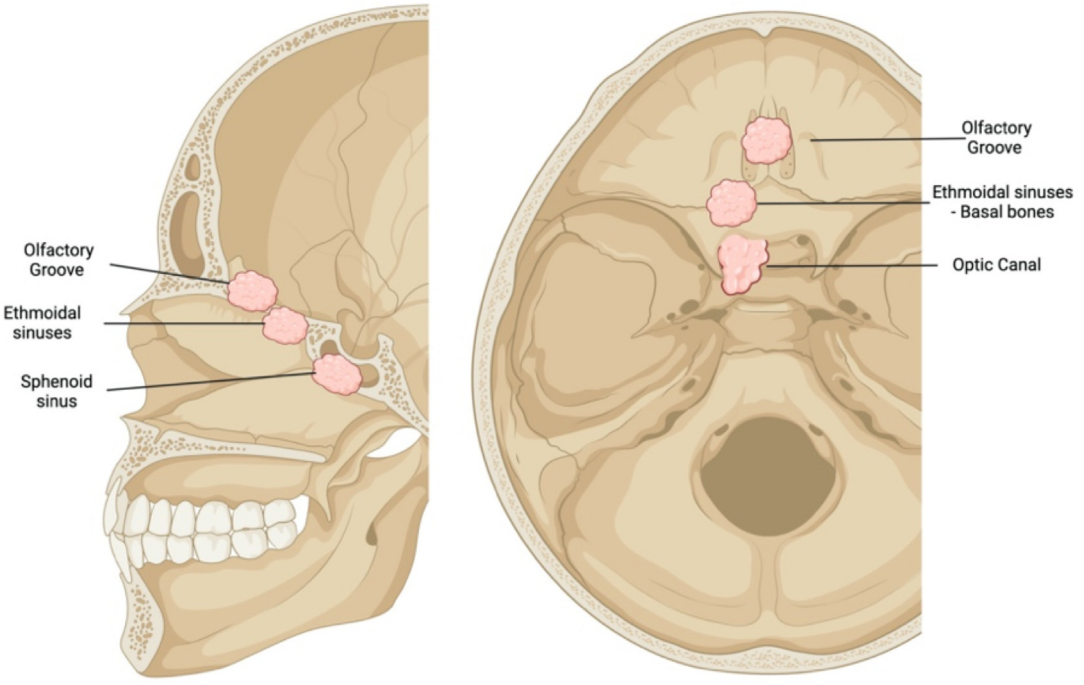

Figure 1. Main locations of olfactory groove meningioma recurrences treated by a transcranial approach.

resection in patients with extensive infiltration of bone and sinuses must be carefully evaluated.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Francesco Maiuri: Writing — original draft, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jacopo Berardinelli:** Methodology, Investigation, Formal analysis, Data curation. **Giuseppe Corazzelli:** Methodology, Investigation, Formal analysis, Data curation. **Federico Russo:** Resources, Investigation, Formal analysis, Data curation. **Sergio Corvino:** Writing — review & editing, Validation, Methodology, Funding acquisition, Data curation, Conceptualization.

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