Transfrontal-Sinus-Subcranial Approach to Olfactory Groove Meningiomas: Surgical Results and Clinical and Functional Outcome in a Consecutive Series of 21 Patients

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■ BACKGROUND: **The transfrontal-sinus-subcranial approach (TFSSA) allows for direct exposure and removal of olfactory groove meningiomas (OGMs), without any brain retraction. Compared with other skull base approaches (e.g., fronto-orbitobasal, transbasal, subcranial, fronto-orbitozygomatic, and one-and-half approach), it could offer the same advantages but is less invasive.**

■ OBJECTIVE: **We report the results in a series of 21 consecutive patients with OGMs and operated on through TFSSA, to propose a viable alternative approach.**

■ METHODS: **Mean maximum tumor diameter was 45.9 ± 3.4 mm (range, 25–70 mm). The aim of surgery was Simpson grade I removal. Surgical, clinical, and functional outcomes were reported. Mean follow-up was 87 ± 7 months (range, 36–176 months).**

■ RESULTS: **In all patients, magnetic resonance imaging after surgery confirmed complete tumor removal. The recurrence-free survival rate was 100% and 85.7% at 5 and 10 years, respectively. Surgery-related mortality and major morbidity were 0% and 4.8%, respectively. Risk of anosmia significantly correlates with meningioma size ($P < 0.001$) and smell sense was preserved only in patients with tumors less than 4 cm in maximum diameter (4/7; 57.1%). A significant improvement of Mini Mental Standard Examination score was recorded at follow-up ($P < 0.001$) and no patients worsened their cognitive profile. Visual function improved in 7/8 (87.5%). Karnofsky Performance Scale score after surgery significantly increased ($P < 0.001$). According to the Glasgow Outcome Score, good outcome was achieved in 20 patients (95.2%).**

■ CONCLUSIONS: **Based on reported results, TFSSA allows complete tumor removal with good outcome and low complication rate. It may be proposed as a safe and effective approach to treat large and giant OGMs.**

INTRODUCTION

After the first successful resection of an olfactory groove meningioma (OGM) in 1885,[1] many approaches have been adopted: from bifrontal and pterional routes to skull base approaches to minimize brain retraction, even if the skull base approaches are too time consuming and technically demanding.[2-9] Furthermore other techniques, such as the endoscopic endonasal approach (EEA) and supraorbital approach have been proposed.[10-18] There are 2 main strategies in the treatment of OGMs. Several investigators recommended the removal of only the visible tumor and dural coagulation,[19-25] whereas others suggested an extensive resection of the meningioma, dura, and bone, particularly in young patients, because recurrence is frequent when a massive tumor infiltration into the ethmoid is evident.[2,5-7,9,26,27]

Key words
- Anterior cranial base
- Meningiomas
- Olfactory groove
- Skull base surgery
- Surgical outcome

Abbreviations and Acronyms
CSF: Cerebrospinal fluid
CT: Computed tomography
EEA: Endoscopic endonasal approach
GOS: Glasgow Outcome Scale
KPS: Karnofsky Performance Scale
MMSE: Mini Mental State Examination
MRI: Magnetic resonance imaging
OGM: Olfactory groove meningioma
SG: Simpson grade
TFSSA: Transfrontal-sinus-subcranial approach
WHO: World Health Organization

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Hyperostosis of underlying bone in OGMs occurred commonly, and it was reported in 17%–78% of cases.[6,10,16,25,28-30] It is generally accepted that hyperostosis is the result of tumor microinvasion.[31] The histologic examinations have shown bone tumor cell infiltration in more than 70% of meningiomas with hyperostosis, probably mediated by a specific pattern of matrix metalloproteinase.[32,33] The frequency of ethmoidal bone invasion (occurring in 15%–73.7% of OGMs) may be supported by the thinness of the cribriform plate.[3-5,7,9,10,16,27,29] The involved bone has to be considered a potential point of recurrence after surgery, shown by the recurrence rate of 30% and 41% reported after 5 and 10 years, respectively.[34]

Bone invasion is not considered among the World Health Organization (WHO) criteria for grading meningiomas; however, there is some evidence that the extent of bone invasion can influence the clinical behavior of meningiomas and patient outcome.[31,33,34]

OBJECTIVE AND STUDY SIZE

Since 2001, the senior author has been using the transfrontal-sinus-subcranial approach (TFSSA), already described,[35] to achieve Simpson grade I (SGI) removal in midline anterior cranial base meningiomas, as a less invasive route, compared with other skull base techniques previously adopted. We report a series of 21 OGMs operated through TFSSA, analyzing surgical results, complications, and clinical and functional outcome.

METHODS

Population and Setting

Twenty-one consecutive patients harboring OGM, operated on through TFSSA from 2001 to 2014 at our institute, were considered. Inclusion criteria were 1) meningiomas originating from the midline anterior cranial fossa, along the dura of the crista galli, cribriform plate, and frontoethmoidal suture, and 2) newly diagnosed meningiomas. Medical charts, surgical records, and radiologic studies of the patients were prospectively collected and retrospectively analyzed. Informed surgical and research consents for data collection were routinely obtained for all patients. All procedures were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Variables, Data Source, and Measurement

All patients underwent complete neurologic and ophthalmologic evaluations before surgery, 6 and 12 months after. Anosmia was evaluated with a questioning test.

The Mini Mental State Examination (MMSE) was performed in all cases, except 1 amaurotic patient, to evaluate the cognitive function. The Karnofsky Performance Scale (KPS) was used to evaluate the functional impairment. The postoperative MMSE, the KPS, and the Glasgow Outcome Scale (GOS) were assessed 12 months after discharge.

All patients underwent head computed tomography (CT) scans before surgery and brain magnetic resonance imaging (MRI) before surgery, 6 and 12 months after surgery, and then yearly. Digital subtraction angiography was performed in only 3 cases of giant meningiomas; all other cases underwent angio-MRI (Figure 1).

The aim of surgery was SGI resection, confirmed on postoperative MRI. Recurrence was considered if new tumor was observable at follow-up MRI evaluation.

Surgical Technique

The patient is placed in the supine position, with the chest raised and the head elevated above the heart level; the head is extended with the vertex toward the floor. A bicoronal skin incision far posterior to the hairline is made. The pericranium and the skin are raised together to expose the orbital rim, the frontozygomatic suture, and the nasal process of the frontal bone up to the frontonasomaxillary suture in the midline. The supraorbital foramina are opened with a chisel and the supraorbital nerve and artery are freed. Six osteotomies are performed with reciprocating saw (Figure 2). The first 2 cuts are made vertically on the sagittal plane along each lateral border of the frontal sinus, usually at the supraorbital foramina/notches, from the orbital rim to the frontal bone. Then, a horizontal cut is made on the axial plane, connecting the previous 2, along the superior border of the frontal sinus. A fourth horizontal osteotomy is made at the level of the frontonasomaxillary suture and extended in depth along each medial orbital wall just anterior to the lacrimal crest. This osteotomy is linked bilaterally to the first 2 made on the orbital rim, completing the 2 cuts along the medial wall and orbital roof. The anterior wall of the frontal sinus is then lifted above with a chisel inserted as levers through the bone cuts. Frontal sinus boundaries can be assessed on CT preoperative images. In case of small sinus, the bone flap has to be extended slightly beyond the superior and lateral limits of the sinus, including the external layer of the frontal vault, which is cut obliquely nearly tangentially to augment the opening surface, allowing TFSSA to be performed in almost all cases.

The sinus mucosa is completely removed and the frontonasal ducts are packed with Surgicel (Ethicon Inc., Sommerville, New Jersey, USA) rolls, powered by vancomycin. The anterior ethmoidal arteries are identified, coagulated, and cut. The posterior wall of the frontal sinus is removed using the diamond burr. The crista galli is dissected from the dura mater and removed. In case of extension of the meningioma into the ethmoid, olfactory filaments are coagulated and cut at the extradural side, and the dura mater is dissected from the cribriform plate. The cranial base is drilled according to the bone invasion.

The dura mater is opened transversely on both sides of the midline near to the olfactory grooves. After coagulation of its implant, the tumor is debulked using an ultrasonic aspirator. The brain parenchyma is not retracted in any phase of the surgical procedure because gravity takes the frontal lobes away from the surgical field. Some pieces of absorbable hemostatic gelatin sponge are used to keep the brain away from the tumor during the dissection.

After removal of the tumor, a pericranium patch is sutured under the microscope. A wide pedicled frontal pericranium flap is reflected along the anterior cranial base to separate the cranial and