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Anterior Versus Lateral Subfrontal Approaches In Olfactory Groove Meningiomas

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Abstract

Objectives: Olfactory groove meningiomas account for 8-18% of meningiomas in surgical series. They generally remain clinically quiescent during the early stages of tumor growth, and usually present after they had attained a large size. Currently surgical approaches to olfactory groove meningiomas vary depending on the size and extension of' the tumor. This study aimed to evaluate the conventional unilateral or bilateral anterior subfrontal approaches versus the lateral subfrontal approach utilized for resection of olfactory groove meningiomas.
Material & Methods: This series included 20 consecutive cases with olfactory groove meningiomas operated upon at the Neurosurgery Department, El-Minia University. All patients were evaluated clinically and radiologically, and surgical approaches for tumor resection were reported and analyzed. **Results:** Olfactory groove meningiomas occurred mostly among females. They presented with headache, visual and mental changes, epilepsy, and anosmia. Based on volumetric measurements, different sizes were identified; small, medium, large and giant. Most tumors had close relations to the anterior and middle cerebral arteries as well as the optic chiasm. Belter tumor removal and less morbidity were achieved using the unilateral anterior subfrontal and lateral subfrontal approaches than the bilateral anterior subfrontal approach. **Conclusion:** Selection of the appropriate approach for resection of an olfactory groove meningioma depends on tumor size and extension. The lateral subfrontal approach has several advantages that may favor its use for most olfactory groove meningiomas.
KeyWords: Olfactory groove**,** meningiomas, tumor size

Introduction

MIDLINE meningiomas of the anterior cranial fossa may arise at various sites in the region, namely; cribriform plate, planum sphenoidale, limbus, tuberculum seliae and dhiphragma seliae, but they are conventionally classified based on their clinical and radiological presentations into olfactory groove and suprasellar meningiomas[3,6]. Olfactory groove meningiomas account for 8-18% of meningiomas in surgical series. They arise in the midline of the anterior cranial fossa from the region of the crista galli anteriorly to the planum sphenoidale posteriorly, and displace the olfactory tracts laterally and optic chiasm posteriorly[7,10]. The A2 segments of the anterior cerebral arteries are typically displaced posteriorly, but the orbital frontal and frontopolar branches are usually lateral to the tumor and may be involved in the pial supply when these tumors are large. In clinical practice, unless they present with epilepsy, it is unusual to see small olfactory groove meningiomas. They generally remain clinically quiescent during the early stages of tumor growth, and thus present to the neurosurgeon after they had attained a large size[11,12,16]. Currently the surgical approach to olfactory groove meningiomas varies depending on the size and expansion of the tumor, and previous reports have utilized different avenues to achieve gross total lumor resection and minimize operative morbidity related to frontal lobe retraction, injury to vital vascular and neural structures, or development of CSF fistula[16,17]. This study reports the immediate and long-term results of a series of olfactory groove meningiomas operated upon using the conventional unilateral or bilateral anterior subfrontal approaches and the lateral subfrontal approach.

Patients & Methods

This series included 20 cases with olfactory groove meningiomas operated upon at the Neurosurgery Department, EL-Minia University between 2010 and 2013. Diagnostic Modalities: All patients had contrast-enhanced brain CT scans as the initial diagnostic modality. Perifocal lucency was common with large tumors and bone changes were not commonly identified. MR imaging was mainly performed for large tumors to verify tumor location and its relationship to the carotid circulation and optic chiasm.

Preoperative Evaluation: All patients underwent thorough neurological and medical evaluation including cardiac and pulmonary functions. The presence of chronic frontal sinusitis required drainage and antibiotic therapy prior to elective surgery.

Premeditation with phenytoin and adequate doses of corticosteroids was started, several days prior to surgery. Diabetic patients were placed on sliding scale insulin coverage based on blood sugar estimations as soon as corticosteroids were initiated.

Surgical Approaches: Depending on the size of the tumor and surgeons' preferences, different approaches for resection of the tumor were selected.

Unilateral anterior subfrontal approach. A bicoronal scalp incision extended from 1 cm anterior to the tragus over the root of the zygoma to the vertex at the bregma and to the contralateral superior temporal line. The scalp flap was dissected suprapericranially till 2.5cm above the superior orbital margins where the pericranium was sharply dissected from the bone and the flap was retracted subpericranially to preserve the suptratrochlear & supraorbital neurovascular bundles, and also preserve the pericranium for frontal sinus repair. The temporalis muscle was split vertically and 2 lateral bun-holes were placed. The anterior lateral burrhole was placed posterior to the origin of the zygomatic process of the frontal bone, Icm above the fronto-zygomatic suture line. The posterior lateral burr hole was placed 5cm behind the anterior one on the superior temporal line. The pericranium over the midline was then sharply dissected and 2 medial bun-holes were placed. The anterior medial burr hole was placed slightly off the midline just above the medial part of the orbital ridge. The posterior medial burr hole was placed 5 cm behind the anterior one over the lateral edge of the superior sagittal sinus. A pediclled bone flap was then elevated, and the dura opened using a curvilinear low transverse incision which was slightly curved posteriorly at the lateral ends.

Bilateral anterior subfrontal approach. The same scalp incision, and dissection of the scalp flap was applied as in the unilateral approach. Two lateral burr holes were placed at the same previous sites on Ihe non-dominant side, and the other 2 lateral burr holes on the other side were similarly placed just above the superior temporal line. The medial burr holes were placed as one anterior burr hole at the midline just above the glabella, and 2 posterior burr holes on either sides of the superior sagittal sinus, *5* cm behind the orbital ridges. A pediclled bone flap was elevated and hinged on one side. The dura was incised on both sides and the proximal superior sagittal sinus was double ligated and divided. The falcine dura was detached from the crista galli and the frontal lobes were gradually retracted. Lateral sub-frontal approach. The same scalp incision, and dissection of the scalp flap was applied as in the anterior subfrontal approach. A right-sided craniotomy was planned to avoid retraction on the left frontal lobe. The lateral burr holes were placed in the same locations. The medial burr holes were placed in the midpupillary plane lateral to the lateral edge of the frontal air sinus. A pediclled bone flap was then elevated, and the dura opened using a curvilinear incision at the lower border of the flap. Postoperative Management: In the immediate post-operative period, patients were transferred to the ICU and nursed there for the first 24-48 hours. With regards to prophylactic antibiotics, a single cephalosporin was given 1g before induction of anesthesia, and every 3 hours for the duration of the procedure, then 2 g daily for 4 days. For patients who experienced seizures preoperatively, they were returned to the pharmacological regime that best controlled their seizures prior to surgery. For patients who had not experienced seizures, they were maintained on phenytoin for I year then gradual with-drawal was started. The patient started to ambulate gradually from the second postoperative day and skin stitches were removed I week after surgery. The average length for inpatient stay averaged between 7 and 10 days. The patient was seen after 1 & 6 months postoperatively and a contrast-enhanced brain CT was obtained. In terms of long- term follow-up, brain MRI was requested I year following surgery as valuable baseline for evaluating the potential of any residual or recurrent tumor, and if negative, a final image was obtained 2 years later. Statistical Analysis: All data was tabulated to determine the correlation of study parameters. Univariate and bivariate statistical analyses were done using the chi-square (X2) method. Statistical significance was defined as P value less than, 0.05.

Results

Demographic & Clinical Data: Sex & Age The study group included 4(20%) males and 16(80%) females. The mean age was (44.7 years) with 10(50%) patients below 40 years and 10(50%) patients at or above 40 years of age. All 4(100%) male patients belonged to the younger age group below 40 years, whereas 6(37.5%) females were below 40 years and 10 (62.5%) females belonged to the elderly group at or above 40 years. (Table I). Symptoms & Signs Headache was the most common presenting symptom among 14(70%) patients. Visual changes occurred among 12(60%) patients, and mental changes among 10(50%) patients. Epilepsy occurred as the only presentation or in association with other symptoms in 8(40%) patients; On the other hand, bilateral (complete) anosmia was present only in 6(30%) patients.

Regarding their physical findings, 10(50%) patients had bilateral papilledema, and 4 (20%) patients had bilateral optic atrophy, (Table 2). Radiological Data: Size Olfa-ctory groove meningiomas had different sizes, and according to each dimensional measurement, tumors were classified into; grade I (2-<3.5 cm), grade II (3.5-<5 cm), grade III (5-<6.5 cm), and grade IV (? 6.5cm). According to their anteroposterior diameter, 6(30%) tumors were grade I, 2 (10%) tumors were grade II, 10(50%) tumors were grade III, and 2 (10%) tumors were grade IV. According to their transverse diameter, 2(10%) tumors were grade I, 6(30%) tumors were grade II, 8(40%) tumors were grade III, and 4(20%) tumors were grade IV. According to their height, 6(30%) tumors were grade I, 8(40%) tumors were grade II, and 6(30%) tumors were grade III. Based on their 3-d measurements, and according to the formula for volumetric calculation of elliptical masses; V = (X.Y.Z / 6"[131, the total volume of the meningioma was calculated and we classified tumors into; small (<30 cc), medium (30-<60 cc), large (60-<90 cc), and giant (90 cc). Among the study group and based on their volumetric classification, 6 (30%) tumors were small, 4(20%) tumors were medium, 6 (30%) tumors were large, and 4 (20%) tumors were giant, (Table 3). Extension According to their size, olfactory groove meningiomas varied in their posterior and superior extensions. Based on their posterior extension, the posterior capsule was confined within the anterior cranial fossa in 11(55%) tumors i.e. "presellar", whereas in 9(45%) tumors the posterior capsule extended into the suprasellar region i.e. "juxtasellar". Superiorly, 10(50%) tumors were located below the falx i.e. "subfalcine", whereas 10(50%) tumors extended beyond the falx and encasing it i.e. "parafalcine", (Table 3). Relation to the carotid circulation According to the size and extension of the rumor on MR imaging, the anterior cerebral arteries were undis-placed in 4(20%) cases and laterally stret-ched in 16(80%) cases. On the other hand, the middle cerebral arteries were un-displaced in 10(50%) cases and posteriorly stretched in 10(50%) cases.

Relation to the optic chiasm According to the size and extension of the tumor on MR imaging the optic chiasm was undisplaced in 6(30%) cases, abutted in 10(50%) cases, and stretched in 4(20%) cases.

Surgical approach According to tumor size, extension and surgeons' preferences, tumor removal was attempted using the unilateral anterior subfrontal approach in 4(20%) cases, the bifrontal approach in 10(50%) cases, and the lateral subfrontal approach in 6(30%) cases. The unilateral sub-frontal approach was exclusively used for small tumors, whereas the other 2 approaches were utilized for larger tumor sizes i.e. medium, large and giant.

Consistency Among all patients, intra-operative assessment of tumor consistency showed that the lesion was firm in 12(60%) cases, and degenerated in 8(40%) cases.

Vascularity Among all patients, intra-operative assessment of tumor vascularity showed that the lesion had moderate vascularity in 14(70%) cases and high vascularity in 6(30%) cases.

Tumor removal Tumor removal using all different approaches was total in 16(80%) cases, and subtotal in 4(20%) cases. Total tumor removal was achieved in all 4(100%) cases using the unilateral subfrontal approach, as well as in all 6(100%) cases using the lateral subfrontal approach. Subtotal removal occurred in 4(40%) cases operated through the bilateral subfrontal approach. Intraoperative complications. Among the whole series, intraoperative hemorrhage occurred in 4(20%) cases that were operated upon using the bilateral subfrontal approach, and brain swelling occurred in 2(10%) cases that were operated upon using the lateral subfrontal approach. Postoperative Follow-up:

Postoperative complications postopera-tively, 2(10%) patients had permanent neurological deficit. Deep vein thrombosis (DVT) of the lower limbs developed in 2(10%) patients, and wound infection occurred in 2(10%) patients. These patients received medical treatment and were cured without residual morbidity.

Biopsy Histopathothological examination of tumor specimens among all patients, verified that the lesion was meningothelial meningioma in 14(70%) cases, and psamm-omatous meningioma in 6(30%) cases.

Table 1: Age/Sex distribution among 20 patients with olfactory groove meningiomas

Age/Sex	Frequency		Total	Percent
	< 40 Ys	**≥ 40 Ys**		
Male	4	0	4	20
Female	6	10	16	80
Total	10	10	20	
Percent	50	50		100

Table 2: Initial clinical presenting features among 20 patients with olfactory groove meningiomas

Presentation	Frequency	Percent
Headache	14	70
Visual changes	12	60
Mental changes	10	50
Epilepsy	8	40
Anosmia	6	30

Table 3: Size/Extension distribution among 20 patients with olfactory groove meningiomas

	Superior extension			**Posterior extension**	
	Subfalcine	**Parafalcine**		**Presellar**	**Juxtasellar**
Small	6	0		6	0
Medium	3	1		4	0
Large	1	5		1	5
Giant	0	4		0	4
Total	10	10		11	9
Percent	50	50		55	45

Table 4: Tumor relationship to carotid circulation and optic chiasm among 20 patients with olfactory groove meningiomas

Optic Chiasm	**Middle C.A.**	**Anterior C.A**	**Presentation**
6	10	4	**Headache**
10	0	0	**Abutted**
4	10	16	**Stretched**

Table 5: Review of retrospective series on surgery of olfactory groove meningiomas

Deaths			**Total removal**			**Series cases**	
%	**No**		**%**	**No**		**No**	
32	6		68.5	13		19	**Cushing (1938)**
33	6		50	9		18	**Holub**
17.3	13		93.3	70		75	**Olivecrona (1967)**
12	3		76	19		25	**Bakay (1972)**
0	0		100	18		18	**Symon (1977)**
17.3	17		93.9	92		98	**Solero (1982)**
15	1		100	18		18	**Mayfrank (1996)**

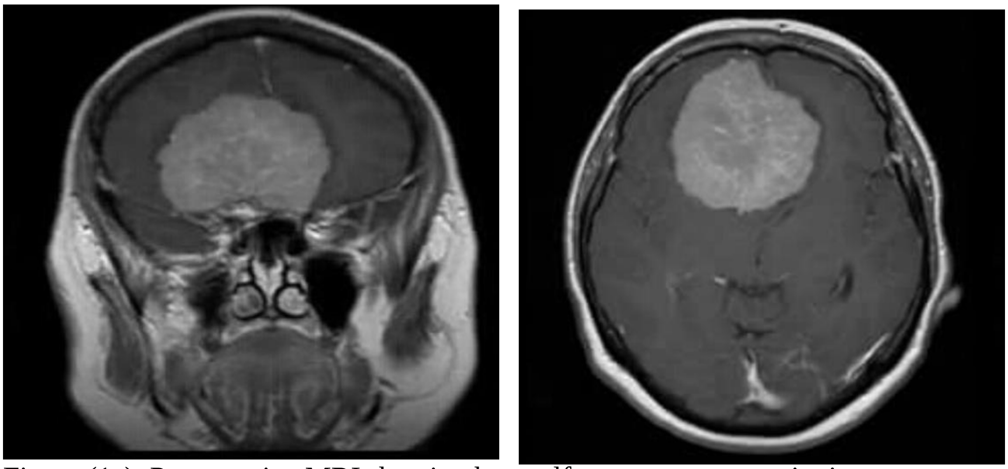

Figure (1a): Preoperative MRI showing huge olfactory groove meningioma

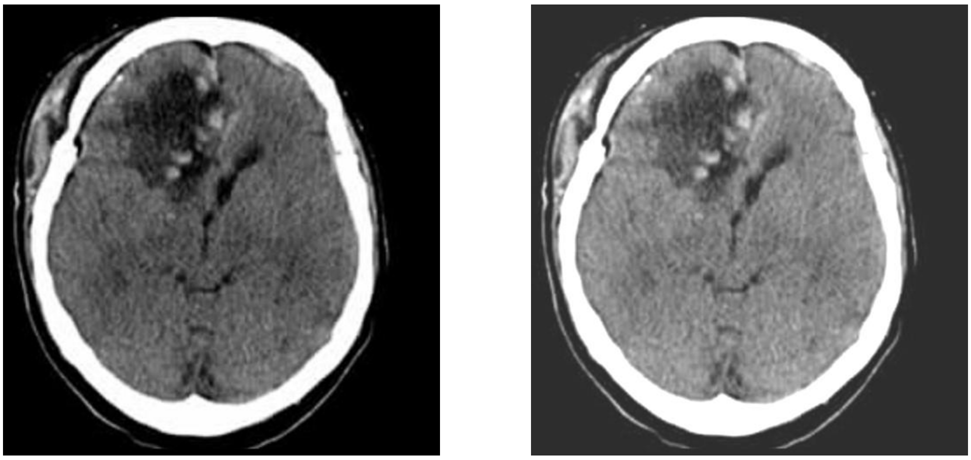

Figure (1B): Postperative CT showing huge olfactory groove meningioma after excision.

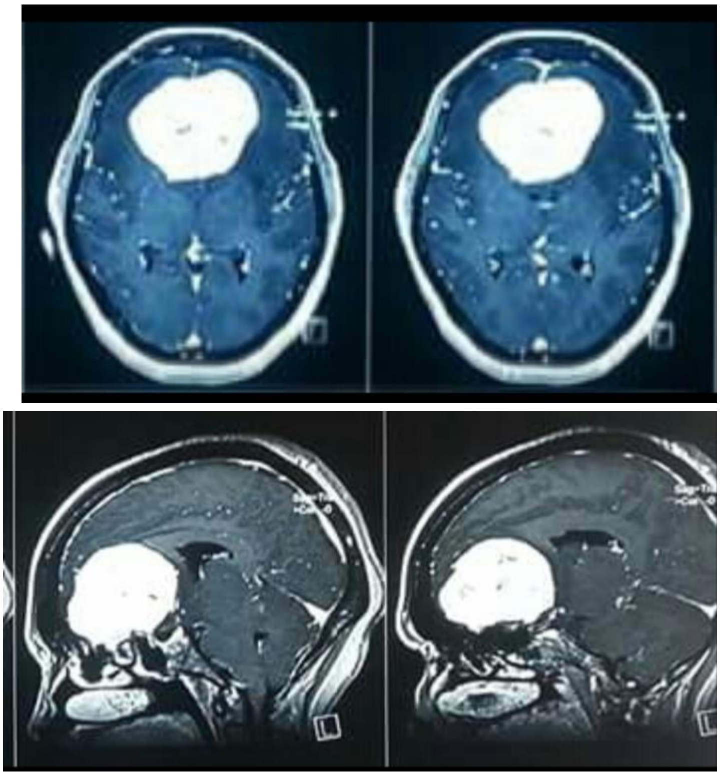

Figure (2 a): Preoperative MRI showing olfactory groove meningioma

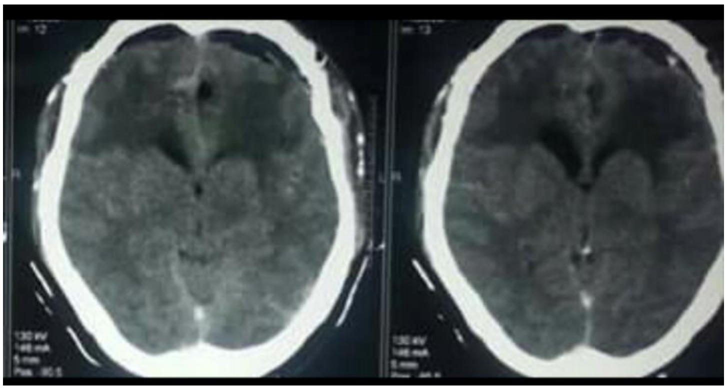

Figure (2B): Postperative CT showing olfactory groove meningioma after excision.

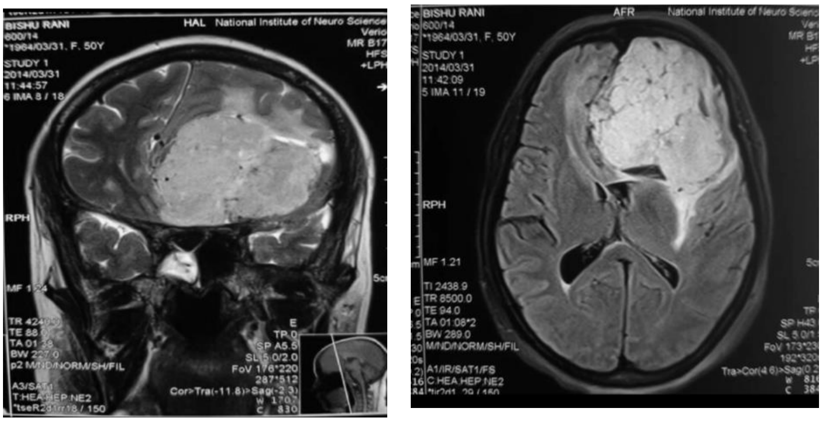

Figure (3 a): Preoperative MRI showing olfactory groove meningioma

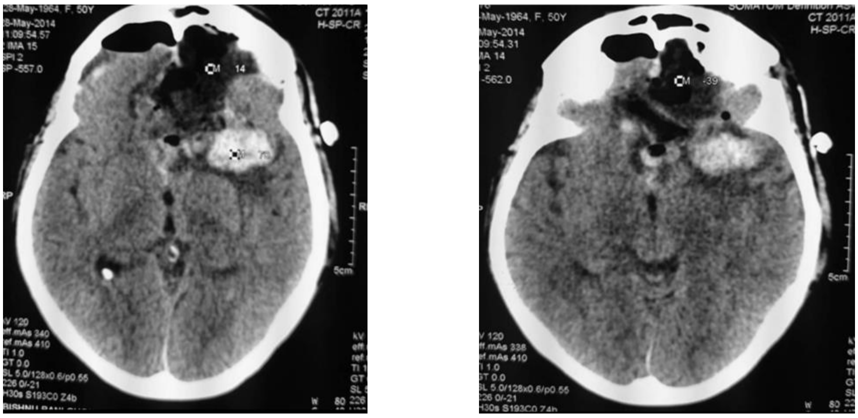

Figure (3B): Postperative CT showing olfactory groove meningioma after excision.

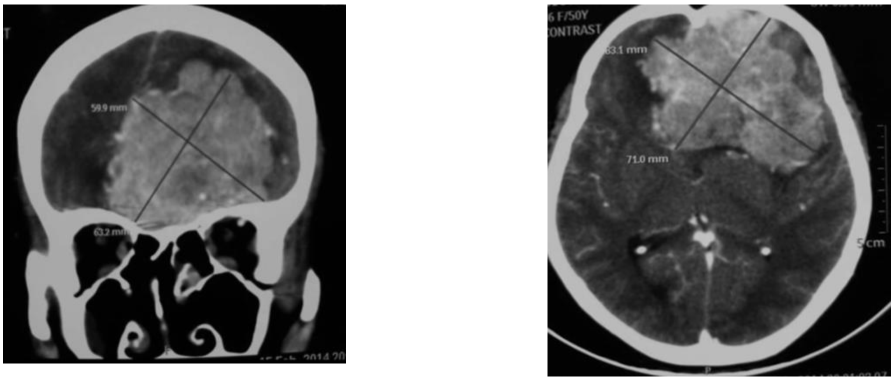

Figure (4 a): Preoperative MRI showing olfactory groove meningiomas

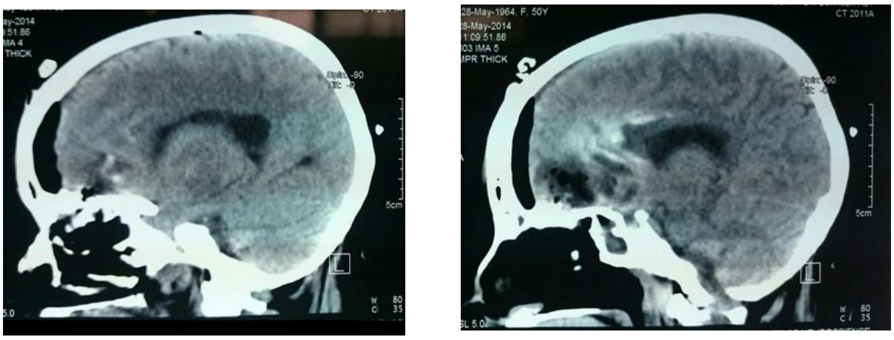

Figure (4B): Postperative CT showing olfactory groove meningioma after excision.

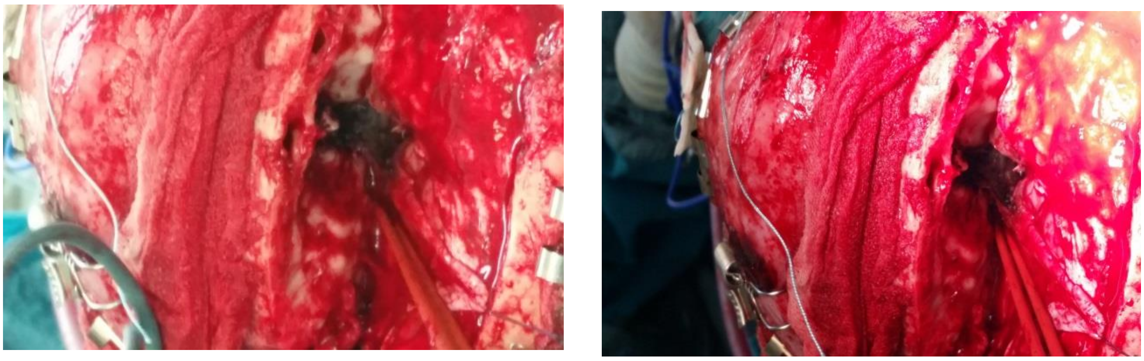

Figure (5): Intra operative picture show excision of tumor by anterior subfrontal approach

Discussion

Olfactory groove meningiomas arise in the anterior cranial fossa at the cribriform plate of the ethmoid bone and the area of the suture adjoining the planum sphenoidale. The most common clinical presentation is a slow onset of mental changes, particularly mood, insight, judgment, and motivation. Late in their course, patients may complain of headache, visual impairment and may have seizures. Rarely do patients complain of loss of sense of smell, and the Foster-Kennedy syndrome attributed to tumor in this location is, in fact, uncommon. In our series, headache was the most common complaint and according to patient's variations and tumor characteristics, could be attributed to several factors as increased intracranial pressure, epilepsy, and vascular phenomena. Visual changes occurred among female patients common with large, firm tumors and moderate vascularity. This could be explained by effects of chronic increased intracranial pressure and visual impairment. Mental changes occurred similarly among female patients having large tumors with higher predisposition among elderly patients. These changes are probably due to the effects of increased intracranial pressure as well as cerebral ischemia prevalent among the elderly.

On the other hand, epilepsy occurred among male patients with small tumors as well as patients with degenerated, highly vascular tumors. The occurrence of epilepsy among these patients may be attributed to steal phenomenon from nearby epileptogenic cortex in a mechanism similar to that of arteriovenous malformations. The lower incidence of occurrence of anosmia is probably due to the high resistance of the olfactory tracts to slow progressive stretch by the tumor. Currently MRI with gadolinium is the investigative procedure of choice. CT with bone algorithms reveals bone changes such as erosion or hyperostosis, and three-dimensional CT delineates any bony defect in the anterior cranial fossa, aiding in preoperative planning for the skull base repair either with pericranial flap or fascia lata femoris graft. In our study, MR imaging was valuable in delineating the tumor size and growth extensions. We were able to identify 4 categories of tumor size based on volumetric measurement namely; small, medium, large and giant. Regarding their extension, most olfactory groove meningiomas reached posteriorly to or into the borders of the suprasellar region, whereas their superior extent reached below or beyond the edge of the falx. These various tumor sizes and their directional extensions in analysis with different approaches studied were helpful in prospecting the selection of the appropriate approach for each category. Although the primary blood supply to olfactory groove meningiomas usually comes from branches of the anterior/or posterior ethmoidal arteries at the anterior skull base, yet these tumors have important relations to the anterior cerebral arteries that are usually pushed aside by the tumor, sometimes being entangled within the tumor capsule. Among our cases, most olfactory groove meningiomas had close relation to branches of the carotid circulation, namely the anterior cerebral and middle cerebral arteries as well as the optic apparatus. The anterior cerebral arteries were stretched in 80% of cases, and 50% of these tumors resulted in stretch of the middle cerebral arteries. The optic chiasm was in intimate relation to the posterior capsule in 70% of tumors. Surgical Approaches: Although large olfactory groove meningiomas present in the midline, tumor volume is often unequally distributed to one side. Currently, the surgical approach to an olfactory groove meningioma can vary depending on the size and expansion of the tumor, yet, most surgeons favor a bifrontal craniotomy with retraction or partial resection of the frontal lobes to resect these tumors. A literature review revealed a number of previous retrospective series which showed that mortality figures were greater before the 1950, (Table 5). With later advances in diagnostic tools and surgical armamentarium, several approaches were introduced for resection of olfactory groove meningiomas as the pterional approach[4], interhemispheric approach[9], bilateral fronto-orbitonasal approach[8], frontal sinus approach[5], extensive transfrontal approach[15]. Ojemann[12], preferred bifrontal craniotomy for large olfactory groove meningiomas, because he felt this resulted in the least amount of frontal lobe retraction, giving access to all sides of the tumor as well as allowing surgeons to decompress the tumor while working to interrupt the blood supply along the skull base. A bifrontal approach was also advocated by McCarthy, and Symon[10,14]. Hassler and Zentner[14], have described the pterional approach for removal of olfactory groove meningiomas, and compared this with frontal approach. They experienced several advantages for this approach; early dissection of the posterior pole of the tumor releasing it from the optic nerves and cerebral vessels, avoiding compression of the frontal veins during elevation of the frontal lobes, and leaving the frontal air sinus and the superior sagittal sinus unin-volved. Al-Mefty[1], prefers a supraorbital approach to gain low basal exposure, making the frontal craniotomy unilateral or bilateral depending on the size of the tumor. In his opinion that opening the frontal air sinus during cranial base procedures is not a major cause of morbidity, because the sinus can be easily repaired. He discussed the unique value of the pterional approach in allowing early dissection of the posterior pole, however this advantage is outweighed by the fact that the operative site becomes obscured by the blood if the feeding vessels near the cribriform plate in the midline are not dealt with in the initial stages. Babu et al.,[2], described a unilateral fronto-orbitul approach adding an orbital osteotomy to a unilateral frontal craniotomy. Their opinion that this approach added to the exposure gained through a unilateral frontal craniotomy even in giant tumors, and helped to preserve the contralateral olfactory tract. In our series, we studied 3 main approaches, namely the unilateral subfrontal, the bifrontal and the lateral subfrontal approaches. The unilateral subfrontal approach was selected for small tumors which were usually located over the cribriform plate and their height extended below the edge of the falx. Utilizing such approach for this selected group of patients resulted in total resection of the tumor with no morbidity. By getting the lower edge of the craniotomy flush with the supraorbital ridge, frontal lobe retraction was minimal and the frontal air sinus was adequately repaired with no postoperative sequel. Since the tumors of this group were small and subfalcine, there was no need to breach the falx or interrupt the superior sagittal sinus, and their posterior extent was away from any major neurovascular relations so that the posterior capsule was reached with relative safety.

The bifrontal approach was adopted for some cases with medium, large and giant tumor sizes. We found that medium-sized tumors were totally removed with no morbidity, yet after sectioning of the superior sagittal sinus as a routine step in the procedure. On the other hand, for large and giant tumors, the posterior capsule was unavoidably breached in some cases resulting in a major bleed and marked postoperative morbidity. This dreadful complication resulted in subtotal resection of tumors in these cases as well as other cases to avoid this complication. Also we noticed that among cases with tumors resected totally using this approach, the frontal lobes were either over retracted, or the non-dominant frontal lobe was partially resected to facilitate tumor exposure. The lateral sub-frontal approach was similarly adopted for medium, large and giant tumor sizes. We had good experience using this approach to achieve total resection of medium and large tumors. The trajectory for this approach along the sphenoid ridge avoids hassles of opening the syfvian fissure and facilitates access to the anterior, middle and posterior parts of the tumor. For large tumors, devascularization of the tumor feeders was attained after debulking of the tumor and reaching the midline, and the identification of the opticocarotid structures before dissection of the posterior capsule facilitated its resection without intra-operative injury. By using this lateral approach, we also had the advantages of preserving the falx and the superior sagittal sinus, as well as avoiding entry into the frontal air sinus. Among cases with giant tumors resected using this approach, we were able to remove the tumors totally however because some of these tumors extended far superiorly above the edge of the falx i.e. high parafalcine. We had to do some retraction or sacrifice the frontal pole to reach the superior extent of the tumor.

The other side of the tumor was delivered through sectioning the body of the falx without interrupting the superior sagittal sinus i.e. transfalcine route.

Summary

Total resection of olfactory groove meningiomas, necessitates adequate radiological assessment of the tumor size, extension and its relationship to the carotid circulation and the optic chiasm. For small tumors with limited posterior extension and their height reaching below the edge of the falx, the unilateral anterior subfrontal approach is suitable. The utilization of lateral subfrontal approach for small tumors depends on the longitudinal diameter of the tumor whether it is the A-P or transverse diameter, so as to compare it with the unilateral subfrontal approach for the least frontal lobe retraction, although the former has the merit of avoiding the frontal air sinus. For medium tumors, both the bilateral anterior subfrontal approach and the lateral subfrontal approach achieve total tumor resection and no morbidity, yet the lateral approach has the advantages of smaller bony craniotomy, no violation of the frontal air sinus, saving the superior sagittal sinus and the falx. For large tumors with posterior extension into the suprasellar region, the lateral subfrontal approach additionally favors better dissection of the posterior capsule thus avoiding intra-operative injury of optico-carotid structures.

For giant tumors, the use of the lateral subfrontal approach attains better results than the bifrontal approach regarding total tumor resection and less morbidity related to the carotid circulation and optic chiasm, however for these tumors the ipsi lateral frontal lobe is cither immensely retracted or partially resected to give space to reach the superior extent of the tumor on either sides of the falx. Using the bilateral anterior sub-frontal approach for selected giant tumors extending far superiorly above the edge of the falx, may be more suitable, however we recommend lo attack the posterior capsule through a simultaneous lateral trajectory.

Conclusion

Selection of the appropriate approach for resection of an olfactory groove meningioma depends on tumor size and extension. The lateral subfrontal approach has several advantages in comparison with other approaches namely; less frontal lobe retraction, sparing the frontal air sinus, less demand for extensive bony craniotomy or ad-junctive osteotomy, preservation of the superior sagittal sinus, early devascularization of the tumor, favorable secure dissection of the posterior tumor capsule from the anterior cerebral arteries and the optic system, and sparing of the contralateral olfactory tract.

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