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Factors Influencing the Outcome of Surgical Intervention for Parasagittal Meningioma

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Abstract

Aim: **to analyze the factors that influenced the clinical outcome of patients with surgically-treated parasagittal meningiomas.** ***Patients and Methods:*** **a prospective study between 2011 through 2013 was conducted on 20 patients who were surgically treated from the diagnosis of parasagittal meningiomas. Thirteen (65%) were females and seven (35%) were males; age ranged from 14 to 65 years old (mean, 53.8±11.6). Follow-up ranged from 7 to 14 months (mean, 9.54±3.83). Lesions at the middle third of the Superior Sagittal Sinus (SSS) were represented in 11 patients, anterior third lesions (6 patients), then posterior third lesions (3 patients). All the patients were assessed by Computed tomography (CT) and magnetic Resonance imaging (MRI) brain, seven cases with Magnetic Resonance Venography (MRV) examination. Most of patients with anterior third lesions underwent total tumor removal and sinus resection safely. Patients with middle or posterior third lesions had total excision of all extrasinusal tumors and coagulation of the dural attachments. Analysis of the patient outcome was done using Karnofsky performance scale.** ***Results:*** **Tumor removal was grade I (according to Simpson's grading system) in 20% of cases, grade II in 60% of cases, grade III in 10% of cases, and grade IV in the remaining 10% of cases. Total and subtotal tumor resection was achieved in 70% and 20% respectively. Surgery related mortality occurred in 2 cases, and recurrence occurred in one case.** ***Conclusions:*** **conservative surgery for meningiomas that are infiltrating but not obliterating the superior sagittal sinus may be considered adequate for treating these patients.**

Keywords: Parasagittal, Meningioma, Tumor, Sinus, Karnofsky

Introduction

Parasagittal meningiomas are complex lesions with a wide spectrum of clinical and surgical nuances[1]. Parasagittal meningiomas are interesting because of the technical challenges they present in resection and the changing concepts of their general management. Aggressive resection of these tumors means opening the superior sagittal sinus, removing tumor from within it, and somehow reconstituting the sinus. This has been advocated by some as the preferred surgical goal when the sinus is only partially occluded, with sinus repair and venous grafting when necessary[2-5]. Currently, a general approach to these tumors is to resect all tumors and dura involved outside the superior sagittal sinus, and closely follow the residual tumor in the sinus[6].

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Patients and Methods

We described 20 patients with parasagittal meningiomas, all patients were surgically treated in the period from April 2011 to January 2013 at the department of neurosurgery in Suez Canal university hospital. Most of our patients (65%) were females.

Also, lesions at the middle third of the SSS were the most frequent and comprised 55%, anterior third lesions (30%), posterior third lesions (15%). Most of our patients were adults, with a mean age and SD of 53.8 ± 11.6 years (Table1).

Table 1: Age of the patients in different locations along the SSS

Age of the patients (years)	N	Minimum	Maximum	Mean	SD
All patients	20	14	65	53.8	11.6
- Anterior third tumors	6	34	57	50.5	8.6
- Middle third tumors	11	14	65	54.1	14.2
- Posterior third tumors	3	57	61	59.3	2.08

The duration of symptoms ranged from 2 months to 30 months, with a mean and SD of 8.45±3.1 months. Headache was the most frequent symptom (45%), followed by motor weakness, generalized or partial seizures, visual disturbances, and disorientation or behavioral disturbances in descending order of frequency (Table 2).

Table 2: Frequency of Symptoms in Relation to Tumor Location along the SSS

Symptoms	Location along the SSS			Total	
	Anterior third	Middle third	Posterior third	No.	%
Headache	5	3	1	9	45%
Seizures	2	2	0	4	20%
Weakness	2	3	0	5	25%
Visual loss	2	1	1	4	20%
Behavior disturbance	2	0	0	2	10%
Disorientation	1	1	0	2	10%
Aphasia	0	1	0	1	5%
Other	1	1	1	3	15%

SSS= superior sagittal sinus

Neurological signs included pyramidal signs in 35% of patients, limb paresis in 30% of patients, positive Babinski sign in 20% of patients, depressed consciousness level in 15% of patients, and signs of increased intracranial pressure in 10% of patients. Ophthalmic examination revealed papilledema in 15% of patients, visual field defects in 15% of patients, optic atrophy, and sixth nerve palsy in 5% of patients for each (Table 3). Preoperatively all the patients were radiologically assessed by CT and MRI brain. Furthermore, seven cases (six with middle third tumors and one with posterior third tumor) were subjected to MRV examination for accurate assessment of sinus patency, which was confirmed, in four patients, and for proper visualization of venous collaterals. For decision-making, preoperative clinical and radiological data were put together with intraoperative findings (Table 4).

A classification scheme for degree of sinus invasion was used in order to minimize

surgical morbidity, and avoiding direct neurologic deficit, there has been a general move to a less aggressive surgical approach complemented with application of microsurgical techniques. Most of patients with meningioma involving the anterior third of the sinus safely underwent total tumor removal and sinus resection. Patients with meningioma that was infiltrating the middle and posterior third of the sinus had total excision of all extrasinusal tumor and coagulation of the dural attachments when the sinus was not completely occluded, or even subtotal tumor removal when important bridging veins were incorporated within the tumor capsule (Figure 1). All tumors were graded according to the World Health Organization (WHO) classification by a neuropathologist. All patients had both a clinical and a neuroimaging follow-up, follow up period ranged from 7 to 14 months, with a mean 9.54± 3.83 months. Statistical analysis was done by $\chi 2$ and Fisher's Exact tests.

Table 3: Frequency of signs in the patients

Signs	No.	%
Disturbed level of consciousness	3	15%
Increased ICP	2	10%
Motor system		
Decreased motor power	6	30%
Hyperreflexia\hypertonia	7	35%
+ve Babiniski sign	4	20%
Sensory system		
Astereognosis & tactile discrimination	2	10%
Diminished touch sensation	2	10%
Dysthesia	1	5%
Visual system		
Papilledema	3	15%
Secondary optic atrophy	1	5%
Cranial nerves		
Bilateral 6th nerve palsy	1	5%

NB: A patient could be presented by more than one sign

Surgical treatment

Patients with tumors involving the anterior third of the superior sagittal sinus were positioned supinely with the head slightly flexed. For middle third tumors, patients were placed in a supine or lateral position with the head well elevated so that the scalp over the center of the tumor is uppermost. For posterior third tumors, patients were positioned pronely so that the motor cortex falls away by gravity. Otherwise, patients were placed in a lateral position (Figure 2).

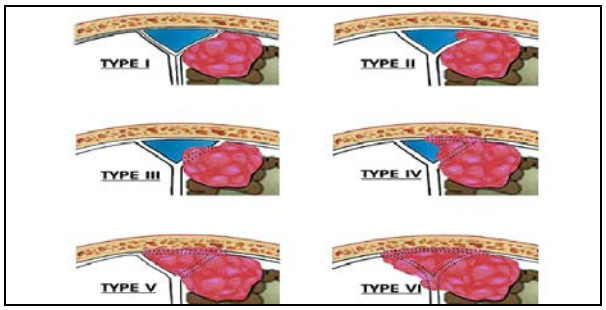
Table 4: Detailed radiological characteristics of meningiomas

Feature	No.	%
Meningiomas size (max diameter)		
Small (2.5<5 cm)	4	20%
Medium (5-7.5 cm)	11	55%
Large (> 7.5 cm)	5	25%
Mode of contrast enhancement		
Homogenous	15	75%
Heterogenous	5	25%
Calcifications	3	15%
Dural tail sign	4	20%
Perifocal edema	4	20%
Bony invasion/hyperostosis	6	35%

Bicoronal skin incision was used for meningiomas located at the anterior third of SSS. For the other locations of meningioma along the SSS, a horseshoe shaped incision was used, extending approximately 2 cm across the midline. Free parasagittal bone flap, centered over the tumor and 2-3 cm beyond the tumor boundaries was performed with several burr holes just over the midline in type I and beyond the midline in all other types. If we crossed the midline, craniotomy was performed in two stages: The elevation of a bone flap on the side of the tumor to avoid crossing the sinus in the initial opening; and then the stripping of dura and elevation of a flap on the other side of the sinus. The bone cuts across the midline were performed last to avoid potential sinus injury early in the opening. The Dura was cut around the tumor about 5 to 10 mm from the meningio-

ma. Dural incision was started opposite to the SSS, then curve laterally, along the anterior and posterior limits of the tumor as a horseshoe shape preserving the SSS and the draining cortical veins. The dura was never opened on the opposite side except in type V meningioma when the SSS is completely occluded or in case of bilateral lesions.

Figure 1: Meningioma classification according to sinus invasion



Classification scheme of meningiomas according to the type of sinus invasion. Type I, meningioma attached to the outer surface of the sinus wall; Type II, lateral recess invaded; Type III, ipsilateral wall invaded; Type IV, ipsilateral wall and roof of the sinus both invaded; Type V, sinus totally occluded, but the contralateral wall free of invasion; and Type VI, sinus totally invaded with no walls free of invasion[24]

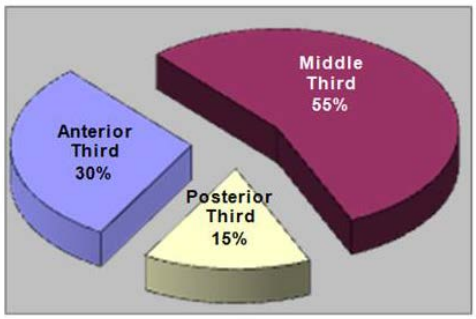


Figure 2: Distribution of lesions according to location along the SSS.

Meningioma was carefully dissected from the adjacent brain under microscopic control. When a blood vessel on the surface of the meningioma was encountered, it must first be identified, and if the vessel supplies the tumor (and not the brain) it may be coagulated on the tumor and cut. Most of the arteries were freed from the tumor provided the small lateral feeding branches are located, and these were coagulated and divided. Few retractions of the adjacent brain were made, as most of those tumors have close relationships with the motor area.

Results

Surgical Outcome

Patients who had lesions with type-I sinus invasion were the most frequent group in our series, they comprised nine patients (45% of the patients). Four lesions (20%) were located at the anterior third, three lesions were located at the middle third (15%) and two lesions (10%) were located at the posterior third of the SSS. Dissection and total excision of the anterior third of the affected SSS was conducted in two patients (10%) achieving excision of a modified Simpson's-I grade (Table 5). The remaining 7 patients (35%) with type I sinus invasion were treated by peeling the outer layer of the sinus wall and coagulation of the dural attachment to achieve the excision of a modified Simpson's-II grade.

Patients who had lesions with type-II sinus invasion were five patients (25%), one patient (5%) had a lesion located at the anterior third, three patients had lesions located at the middle third (15%), and one patient (5%) had lesion located at the posterior third of the SSS. Total excision of the tumor and dissection of the affected sinus was conducted for the patient who had anterior third lesion to achieve a modified Simpson's-I grade. Regarding the other four patients (20%) with type-II sinus invasion, all lesions were located at the posterior two thirds of the SSS (three lesions were located at the middle third, and one lesion was located at the posterior third of the sinus), and a modified Simpson's-II grade had been achieved for the four patients. Patients who had lesions with types-III sinus invasion were two (10%) patients;

both patients had lesions located at the middle third of the SSS, a modified Simpson's-III grade was achieved for both.

Table 5: Simpson's grade of tumor resection in different tumor locations

Simpson's Grade	Tumor Location along the SSS			P
	Anterior third No. (%)	Middle third No. (%)	Posterior third No. (%)	
Grade-I	4 (20)	0	0	0.02
Grade-II	2 (10)	7 (35)	3 (15)	
Grade-III	0	2 (10)	0	
Grade-IV	0	2 (10)	0	
Total	6 (30)	11 (55)	3 (15)	--

Significant at P value of <0.05

In addition, there was one patient (5%) who had middle third lesion, with type-V sinus invasion, the lesion was located at the middle third of the SSS; a modified Simpson's-IV grade was achieved for that patient. Lastly, three patients had lesions with type-VI sinus invasion, one patient (5%) had lesion located at anterior third of the SSS, and the other two patients (10%) had lesions located at the middle third of the SSS. Sinus dissection and complete tumor removal was conducted for the patient with anterior third lesion to achieve a modified Simpson's-I grade. Regarding the other two patients who had middle third lesion, a modified Simpson's-II grade was achieved for one patient, and a modified Simpson's-IV grade was achieved for the other. Repair of the dura mater with considerable defects was conducted using autogenous galea or periosteum in three patients (15%). Cranioplasty (using titanium mesh) was conducted in a patient with anterior third tumor due to a large bone defect left after removal of the invaded bone. Postoperative CT brain revealed that total tumor removal was achieved in 14 patients (70% of patients), subtotal tumor removal in four patients (20% of patients), and partial removal in two patients (10% of patients). Histopathological examination of tumor specimens revealed that 95% of patients (19 patients) had WHO grade I meningiomas, and only one patient (5% of patients) had WHO grade II meningioma. The most frequent subtype of grade I meningioma was meningothelial meningioma which accounted for 45% of patients, followed by transitional meningioma which accounted for 25% of patients. Grade II meningioma comprised only one patient diagnosed as atypical meningioma (Table 6).

Morbidity and Mortality

In this series, the overall complications had occurred 12 times (in 8 patients of the total population). i.e., some patients had more than one complication. In spite of this, most morbidity was recoverable. Two patients developed a postoperative hematoma (10% of patients); one patient developed an acute subdural hematoma and the other developed small intra-cerebral (tumor bed) hematoma. Both patients were managed conservatively, and improved without any permanent neurologic sequelae. Postoperative infection rate in our series was 10%; two patients developed a superficial wound infection. All of these cases did well after frequent wound dressing and antibiotic therapy (Table 7). Transient neurologic worsening in the immediate postoperative period occurred in 3 patients (15% of patients). Two patients with middle third tumors exhibited deterioration of the motor power of the already paretic contralateral limb. Three months after surgery, clinical evaluation showed improvement of their clinical conditions. Another patient with an anterior third lesion developed severe frontal manifestations 4 days after surgery, later on, the patient improved well without any major sequelae. Flail foot was the only recorded permanent deficit in our series, it developed in a female patient with middle third lesion secondary to cortical lacerations during surgery.

Table 6: Meningioma subtypes and grade (WHO classification of brain tumors)

Histological subtype WHO grade	WHO grade
- Meningothelial meningioma	I
- Fibrous (fibroblastic) meningioma	I
- Transitional (mixed) meningioma	I
- Psammomatous meningioma	I
- Angiomatous meningioma	I
- Microcystic meningioma	I
- Secretory meningioma	I
- Lymphoplasmacyte-rich meningioma	I
- Metaplastic meningioma	I
- Chordoid meningioma	II
- Clear cell meningioma	II
- Atypical meningioma	II
- Brain invasive meningioma	II
- Papillary meningioma	III
- Rhabdoid meningioma	III
- Anaplastic (malignant) meningioma	III

Table 7: Reported postoperative complications

Complications	N	%
- Postoperative hematoma	2	10%
- Wound infection	2	10%
- Transient neurologic deficit	3	15%
- Permanent neurologic deficit	1	5%
- Seizure	2	10%
- Chest infection	1	5%
- DVT	1	5%

The patient did not improve after proper postoperative physiotherapy. Other complications included postoperative seizure in two patients (10% of patients) with anterior and middle third tumors, both improved well after parenteral phenytoin reloading. Medical complications comprised 10% of patients; it included transient chest infection in one patient and deep venous thrombosis in another patient. Mortality was observed in two female patients; the first patient had large anterior third meningioma, the patient died one day after surgery secondary to massive intraoperative bleeding from the sinus, this occurred while the surgeon was trying to elevate the bone flap that was extensively invaded by the tumor, resulting in extensive tearing of the sinus wall, and huge amount of blood was lost till repair of the sinus wall and achievement of hemostasis. The other female patient developed immediate postoperative quadriplegia after excision of middle third meningioma, CT brain done and revealed massive venous infarction, and the patient died four days later.

Functional Outcome

Preoperative and postoperative (3-months follow-up) functional disabilities were assessed by Karnofsky performance scale (KPS) (Table 8). For patients who died during the immediate postoperative course, the KPS score acquired before death was used. For the six patients with anterior third tumors, the high rate of total tumor removal had reflected on their outcome at follow up, 4 patients (66%) had KPS scores > 80, one patient (17%) had KPS score <70 and one patient (17%) had KPS score <50 . Regarding patients with middle third tumors, there were more frequent neurologic (mainly motor) deficits, and in some patients neurologic worsening had happened but at final follow up (three months after surgery), re-evaluation showed improvement of clinical conditions in most patients.

Of 11 patients with middle third tumors, 7 patients (63%) had KPS score > 80, 3 patients (26%) had score <70, and one patient (11%) had KPS score <50.

Table 8: Karnofsky Performance Scale rating criteria[24]

- Able to carry on normal activity and to work, - No special care needed.	100: Normal no complaints; no evidence of disease. 90: Able to carry on normal activity; Minor signs or symptoms of disease. 80: Normal activity with efforts; some signs or symptoms of disease.
- Unable to work, able to live at home and care for most Personal needs, varying amount of assistance needed.	70: Cares for self; unable to carry on normal activity or to do active work. 60: Requires occasional assistance, but is able to care for most of his personal needs. 50: Requires considerable assistance and frequent medical care.
- Unable to care for self - Requires equivalent of institutional or hospital care, - Disease may be progressing rapidly	40: Disabled; requires special care and assistance. 30: Severely disabled; hospital admission is indicated although death not imminent. 20: Very sick; hospital admission necessary; Active supportive treatment necessary. 10: Moribund; fatal processes progressing rapidly. 0 : Dead

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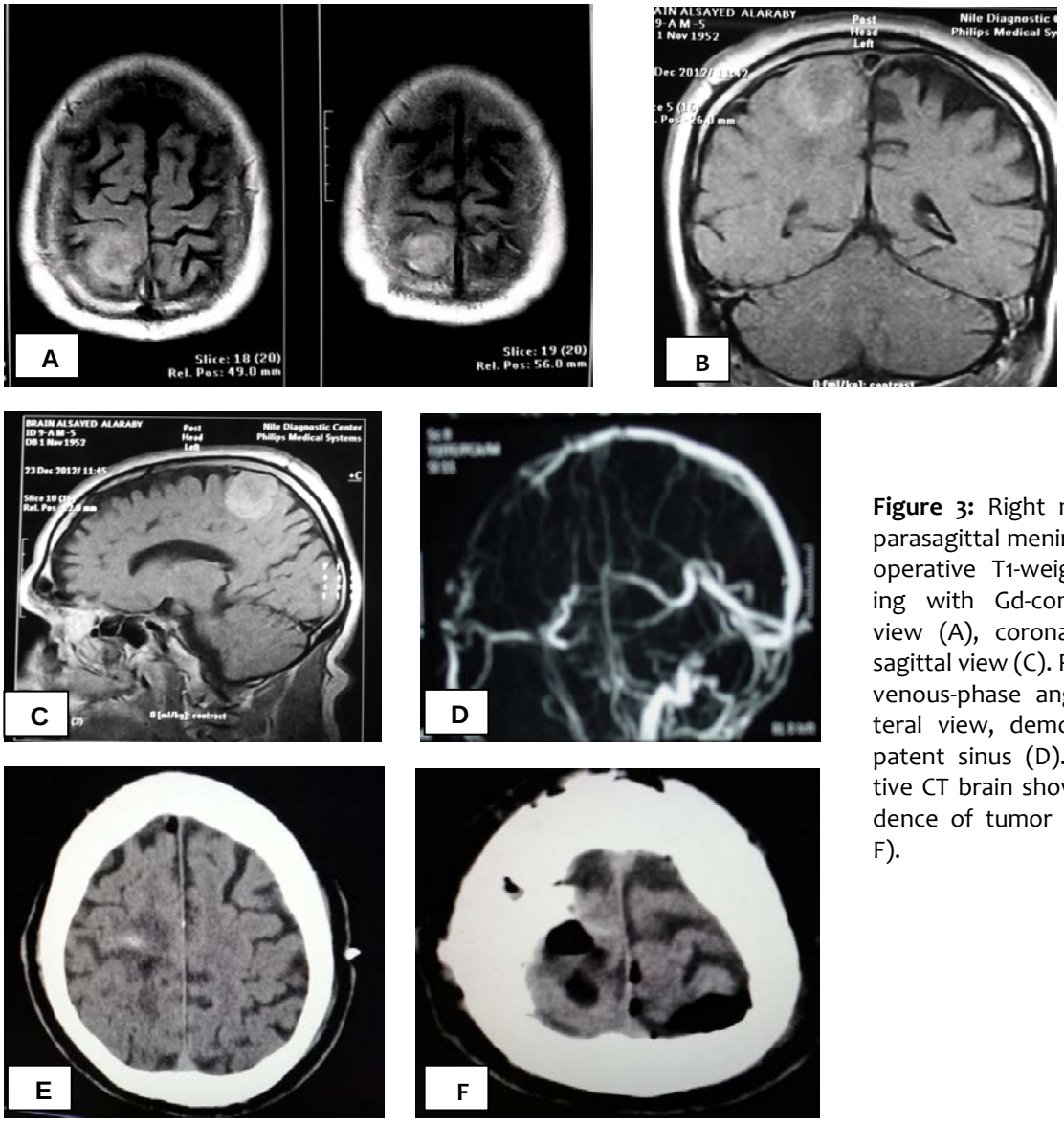

Figure 3: Right middle third parasagittal meningioma. Preoperative T1-weighted imaging with Gd-contrast; axial view (A), coronal view (B), sagittal view (C). Preoperative venous-phase angiogram, lateral view, demonstrating a patent sinus (D). Postoperative CT brain showing no evidence of tumor remnant (E-F).

Discussion

Parasagittal meningiomas are interesting because of the technical challenges they present in resection. Aggressive resection of these tumors means opening the superior sagittal sinus, removing tumor from within it, and somehow reconstituting the sinus[3,6,7]. In the past, surgical techniques for assessing and safely grafting the sinus have been described[8]. Previously, there has been a different approach to these meningiomas. Resection of the sinus, although leading to lower rate of recurrence, increases the risk of hemorrhage, sinus thrombosis, or venous infarction leading to brain edema and neurologic deterioration. This approach has therefore been modified in recent years; with increasing use of radiosurgery as adjunctive treatment for residual tumors after resection of most of the meningioma[9].

Invasion of the sinus is a major problem in the resection of these tumors. It is a general concept that the anterior third of the SSS may be resected without sequelae[5,17], but resection of the posterior two thirds of the sinus may cause severe, permanent damage to the adjacent brain if the sinus is patent. In our series, we observed no morbidity or mortality that could be attributed to ligature of the anterior third of the SSS, which proves this concept. When the sinus is completely occluded, it may be resected without significant risks[5,9,17].

In our series, there were 13 (65%) females and 8 (35%) males with mean age 43±11.0 years ranged from 14 to 65 years. The younger mean age for our patients may be related to availability of ready modern diagnostic tools like MRI or even CT, the relatively small number of patients under study, or the involvement of relatively younger patients like the 14 years old male patient who diagnosed as type II neurofibromatosis. Tumor invading only the external layer of the lateral sinus wall can be completely resected by laminating the external layer of the tumor and preserving the internal layer of the sinus wall. Primary closure of the SSS can be accomplished for tumor invading the lateral angle of the sinus. The piece of tumor attached to the sinus can be resected followed by a progressive running suture along the sinus wall. Resection and reconstruction of the sinus are feasible, but they may be followed by significant morbidity[5,11]. In our series, we choose to perform a subtotal resection when the posterior two thirds of the sinus were significantly invaded by a tumor and we never interrupted nor reconstructed the sinus.

Morbidity after resection of parasagittal meningiomas remains significant. Transient neurologic worsening in the immediate postoperative period developed in 15% of our patients. Di Meco et al reported that this worsening was observed in 8.3% in his series [9] and was related to the great size of the tumor and to the location in the middle and posterior third of the SSS, the author speculated that this impairment was caused by transitory venous engorgement and difficulties in venous drainage caused by sinus stenosis in the event of marginal resection. Other operative complications were intracranial hematomas in two patients, wound infection in 2 patients, and new onset of seizures in two patients. Non-neurologic complications included one patient with deep venous thrombosis, and another patient with chest infection. We also observed permanent neurologic deterioration in one patient. Most of neurologic deterioration occurred in patients with tumors located in the middle third of the SSS. As these complications are generally caused by interruption of the SSS or by lesion of cortical veins draining to the SSS,

every effort should be exerted to preserve the bridging veins located over or anterior or posterior to the tumor to avoid surgical interruption or inducing thrombosis of such veins which could lead to regional venous infarction with delayed neurologic deficit.

Operative mortality for resection of parasagittal meningiomas varied from 1.85% to 12.3%[6,8,9,10,12]. The overall mortality observed in our series was 10%, Surgery-related deaths were caused by circulatory shock in 1 patient, and by venous infarction in another patient. Mortality is associated significantly with old age[19], is greater for patients with tumor located in the middle third of the sinus, and does not depend on the extension of the resection[9,10]. Di Meco et al[9] reported a decrease from 3.7% to 1.85% in operative mortality after the introduction of microsurgical techniques in the treatment of patients with parasagittal meningiomas operated on from 1986 to 2001. Causes of death among the patients of Giombini et al[10] were predominantly cerebral swelling, followed by pulmonary embolism, postoperative hematoma, cardiac failure, and bronchopneumonia. Predominance of cerebral swelling in patients with tumor in the middle third of the SSS probably indicates surgical damage to cortical veins closely related to the tumor.

Recurrence of parasagittal meningiomas occurs in 7.9% to 29%[3,6,9,13,16,20], and is dependent on the extent of the follow-up. Recurrence rate in all the follow-up in our series was 5%. Most authors agree that recurrence rates for patients with atypical or malignant meningiomas are greater than for patients with WHO grade I[1,2,13,14,15,18,21], and this is also true for patients with parasagittal meningiomas as demonstrated by Di Meco et al[9]. Many factors are reputed to influence the recurrence of all intracranial meningiomas. Simpson, in 1957[20], established the recurrence of meningiomas according to the extent of resection, and since then other authors have confirmed his findings[6,9,13].

Postoperative functional outcome worsening is not uncommon, functional outcome sometimes may worsen after surgical treatment of parasagittal meningiomas. Di Meco[9] reported an immediate postoperative worsening of preexisting condition in 11.1% of cases and most of them improved sometime later, after the improvement of the neurologic deficit. In our series, 30% of patients had a worse immediate postoperative KPS than preoperatively, but 15% had an immediate postoperative improvement of the KPS. There was no influence of the sinus invasion grade and of the location of the tumor along the SSS in the postoperative functional outcome.

Conclusions

Our results demonstrated that the approach used for this group of parasagittal meningioma patients, which consisted of a less aggressive resection in cases of tumor invasion of a patent SSS, with employment of microsurgical tools and techniques allowed excellent neurovascular control and resection of most of the tumor tissues. Leaving a small tumor residue in place rather than achieving complete tumor removal with sinus reconstruction proved to be reasonable choice, the residual tumor in the event of subsequent growth can be treated with radiosurgery or repeated surgery without exposing the patient to the risks of aggressive surgery.

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