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The Surgical Outcome of Parasagittal and Falx Meningioma in the Era of Microsurgery and Computerized Tomography

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Abstract In this paper we present our experience in the surgical treatment of supratentiorial midline meningiomas including 23 parasagittal and 15 falx meningiomas since the introduction of CT and routine use of microsurgical techniques. The immediate and late outcomes were analyzed. There were 17 meningiomas in the anterior third of the superior sagittal sinus; 15 in the middle third and 6 in posterior third. There were 12 males and 26 females. The age ranged from 29 to 84 years old with an average of 56.6. Thirty six cases were evaluated with CT preoperatively, and two with magnetic resonance imaging. Surgical excision was performed with microsurgical techniques. The carbon dioxide laser was used in 13 recent cases. The extent of the tumor removal was expressed according to Simpson's classification[22]. Grade I removal was performed in 13 of 17 anterior third tumors; 2 of 15 middle third; and 1 of the 6 posterior third tumors. Grade II removal was performed in 2 of the 17 anterior third; 10 of 15 middle third; and 4 of 6 posterior third tumors. Grade III removal was performed in 1 anterior third; 2 middle third; and 1 posterior third tumors. Grade IV removal was performed in 1 anterior third tumor and 1 middle third tumor. The operative mortality was 2.6% (1 out of 38). Sixteen patients (42.1%) were neurologically intact pre and postoperatively. The functional capability in 24 survivors with the follow-up period longer than 4 years (mean of 6 years) were: no disability in 14 patients (58.3%), partial disability but independent in 7 (29.2%), and complete disabiligy in 3 (12.5%). The immediate and late outcomes of present series were better than those of earlier reported series in which the majority of the cases were diagnosed with angiography and treated with conventional surgical techniques. Early accurate diagnosis with CT scan with refinements of surgical techniques, such as routine use of microsurgery, have improved surgical outcomes, but did not reduce the recurrence rate which was the most ominous factor in terms of long term prognosis in the supratentorial midline meningiomas.

Key Words: Parasagittal meningioma, Falx meningioma, Surgical treatment, Late surgical outcomes

Introduction

In view of supratentorial location and usually benign histological nature, the parasagittal and falx meningiomas seem to be potentially curable tumors by surgical resection. However, the immediate and late outcomes of the surgical resection of these tumors in most previously reported series have not been satisfactory[7,12,13,15,17]. The major reasons of this dissatisfaction are high operative mortality, high recurrence rate and

a poor functional outcome. The operative mortality of these tumors was higher (3.8% in the series of Logue in 1975 [17]), than that for acoustic neuroma (2.5% in the series of Ojemann in 1978 [19]). Parasagittal and falx meningiomas had the highest rate of recurrence among intracranial meningiomas[22]. Recurrence contributes to high mortality in association with repeated operations[17,18,22]. The quality of life in recurrence-free patients was often handicapped by permanet neurological deficits or by epilepsy[12,13]. the difficulties encountered during the operation included large size tumor, high vascularity and extensive involvement of the dural sinus and of major cortical veins. Improvement in the surgical outcomes had been expected with the new diagnostic aids and refinement of surgical techniques and instrumentations. The purpose of this paper is to evaluate the contribution of routine use of CT scan and microsurgical technique to the surgical outcome of the parasagittal and falx meningiomas.

Clinical Material and Methods

Thirty eight patients with parasagittal or falx meningioma were surgically treated at Good Samaritan Hospital in Cincinnati from 1975 through early 1987. There were 12 males and 26 females. The ages ranged from 29 to 84 with an average of 56.6 years. The location of the tumor is listed in Table 1-A. There were 17 meningiomas in anterior third, 15 in middle third and 6 in posterior third of the convexity. The parasagittal meningioma is generally attached to the superior sagittal sinus and occupies the space between the falx and convexity dura, indenting the medial surface of the hemisphere. The falx meningioma arises from the falx or inferior sagittal sinus, and is not visible on the surface of the brain. There were 23 parasagittal and 15 falx meningiomas (Table 1-B). The presenting symptoms are summarized in Table 2. Eighteen patients presented with seizure disorders, 21 with slowly progressive neurological deficits and 12

Table 1-A
Location

	anterior 3rd	Middle 3rd	Posterior 3rd	
Right	4	8	2	14
Left	3	6	4	13
Bilateral	10	1	0	11
Total	17	15	6	38

Table 1-B
Types of tumor

	anterior 3rd	Middle 3rd	Posterior 3rd	
Parasagittal	6	12	5	23
Falx	11	3	1	15
Total	17	15	6	38

Table 2
presenting symptoms

	anterior 3rd	middle 3rd	posterior 3rd	Total
Number of cases	17	15	6	38
Seizure disorders	7	8	3	18
focal	2	4	2	
generalized	5	4	1	
Progressive neurological deficits	12	7	2	21
mental symptoms	12	1	2	
motor and/or sensory	0	6	0	
Headache	6	2	4	12

with headaches. Neurological examination on admission (Table 3) showed no abnormality in 18 patients, unilateral pyramidal signs in 11, mental disturbances in 10, frontal release signs in 2, homonymous hemianopsia in 2 and bilateral pyramidal signs in 1. Thirty six patients were evaluated with computerized tomography (CT) scan and cerebral angiogram. Two patients in 1975 were diagnosed with neuclear brain scan. Magnetic resonance imaging (MRI) was performed in 2 of recent cases. Surgical treatment included microsurgical techniques and carbo-dioxide (CO_2) laser. The laser was used in 13 recent cases. The extent of tumor removal was expressed according to Simpson's grading[22]. Follow-up data was obtained by reviewing patient's records and/or telephone contact with patients or family members.

Results

Results of surgery is summarized in Table 4 according to the estimates of the surgeons at the time of operation and postoperative CT findings. Invasion into the superior sagittal sinus was seen in 3 patients with anterior third, 7 patients with middle third and 2 patients with posterior third meningiomas. Grade I operation was accomplished in 13 out of 17 anterior third meningiomas, in 2 out of 15 in the middle third and in 1 out of 6 posterior third. Grade II operation was performed in 10 out of 15 middle third tumors and in 4 out of 6 posterior third tumors. In the Grade II operation, the dural attachment was coagulated with bipolar cautery and, in recent cases, with the CO_2 laser. Grade III and IV operations were performed in 6 out of the 38 patients. This low incidence of incomplete removal may be a reflection of earlier diagnosis and the advances in surgical techniques. There was one postoperative death in this series. The patient was an 84-year-old male with right parietal parasagittal meningioma. The patient died of pneumonia and ileus two weeks after the operation. The histological types of tumor were syncytial in 10, transitional in 14, fibroblastic in 1, and angioblastic in 1. Malignant features such as invasion to the brain, necrotic foci and mitosis were observed in 6 cases, 4 of which were associated with tumor recurrence. Postoperative neurological deficits were compared with preoperative deficits at the time of discharge from the hospital. Sixteen (42.1%) patients were neurologically intact pre and postoperatively. Neurological status improved in 7(18.4%) and unchanged in 6(15.8%) patients. Previous neurological deficit worsened in 3 cases and new neurological deficits developed in 5 cases. Complications are summarized in Table 5. Pneumonia was most common,

Table 3
Preoperative neuological sings

	anterior 3rd	middle 3rd	posterior 3rd	Total
No abnormal signs	9	6	3	18
Mental disturbances	9	1	0	10
Frontal release signs	2	0	0	2
Unilateral pyramidal signs	2	7	2	11
Bilateral pyramidal signs	1	0	0	1
Homonymous hemianopsia	0	0	2	2
total/cases	23/17	14/15	7/6	44/38

Table 4
Operations

Simpson's grade	anterior 3rd	middle 3rd	posterior 3rd	Total
Grade I	13	2	1	16
Grade II	2	10	4	16
Grade III	1	2	1	4
Grade IV	1	1	0	2
	17	15	6	38

seen in 5 cases. CSF rhinorrhea was seen in 2 cases of anterior third location. Severe postoperative brain edema was encountered in 1 case of posterior third meningioma. Delayed thrombosis of sagittal sinus caused neurological deterioration in 1 patient. This event occurred 2 years after the operation and was associated with recurrence of tumor. The late outcome of the survivors who had been operated upon for the first time at least four years earlier (mean follow-up period of 6 years) is shown in Table 6. There were 24 such patients in this series with 14 anterior third, 9 middle third and 1 posterior third meningiomas. Fourteen patients (58.3%) had no disability, 7 patients (29.1%) lived independently with partial disability including focal neurological deficits and 3 patients (12.5%) were completely disabled requiring constant care. Recurrence was encountered in 6 cases (Table 7). The interval between the first and second operation ranged from 6 months to 6 years with a mean of 4 years. In these 6 cases, the location of tumors was middle third in 4 and posterior third in 1 and anterior third in 1. There were 4 parasagittal and 2 falx meningiomas. In 4 cases of parasagittal meningiomas, the tumors involved the superior sagittal sinus without occluding it at the first operation. Therefore, the tumors were resected and attachments were coagulated (Grade II) in 3 cases and the tumor was resected partially (Grade IV) in 1 case. In 2 of these parasagittal tumors showed histological features of malignancy. Recurrence occurred after 6 months, 2 years, 3 years, and 4 years respectively. At the time of reoperation, the superior sagittal sinus was occluded by tumor in all 4 cases. The tumors were resected with excision of the involved sinus in all cases. In 1 case, the sinus was reconstructed with a vein graft.

Table 5
Complications

	anterior 3rd	middle 3rd	posterior 3rd	Total
Pneumomia	1	3	1	5
Flap infection	2	2		4
CSF rhinorrhea	2			2
Post-op hematoma	2			2
Severe brain edema			1	1
Hydrocephslus		1		1
Transient renal failure			1	1
SIADH			1	1
Plumonary embolism	1			1
SSS thorombosis			1	1
total	8	6	5	19

Post-op : post-operative, SSS : superior sagittal sinus

Table 6
Late outcome
The functional capability of 28 patients with follow-up period longer than 4 years (mean of 6 years).

	anterior 3rd	middle 3rd	posterior 3rd	Total
Survivor	14	9	1	24
No disability	7	6(1)	1	14(1)
Partial disability	4(1)	3	0	7(1)
Complete disability	3	0	0	3
Dead	0	3(3)	1(1)	4(4)
	14(1)	12(4)	2(1)	28(6)

( ) : the number of the patients with recurrence and repeated operation.

Table 7
Cases with recurrence

Age	Location	Type	SSS Invasion	Gradeof Operation	Interval to Recurrebce	Malignant Features in Pathology	Radition	Outcomes
50M	rt posterior	F	−	I	4 years	mitosis necrotic foci invasion to brain	+	died 8 years after the 1st op. (deteriorate after the 3rd op.)
68F	bil anterior	F	−	I	5 years	invasion to brain	−	alive in nursing home 6 years after the 1st op.(deterirate after the 2nd op.)
74M	lt middle	P	+	II	4 years	invasion to brain	−	died 6 years after the 1st op.(deteriorate after the 2nd op.)
61M	rt middle	P	+	IV	2 years	mitosis necrotic foci	−	died 6years after the 1st op.(deteriorate after the 2nd op.)
71F	lt middle	P	+	II	6 months	none	−	dies 2 years after the 1st op.(deteriorate after the 3rd op.)
51F	rt middle	P	+	II	3 years	none	−	doing well 10 months after the 2nd op.

rt : right, lt : left, bil : bilateral, P : parasagittal meningioma, f : falx meningioma, SSS : superior sagittal sinus

Three of these 4 patients worsened neurologically after the second operation and subsequently died of medical complications 1. 5, 2 and 4 years later. One patient was doing well with mild leg weakness 10 months after the second operation. Inthe 2 cases of falx meningiomas, Grade I operation was performed in both cases at the first operation. histological malignant features were seen in both cases. One patient had a recurrence 5 years after the first operation. Radical resection was attempted at the second operation. This patient was alive but disabled in a nursing home 1 year after the second operation. The other patient had a recurrence in 6 years and also underwent the second operation and another recurrence necessitated the third operation. The patient deteriorated neurologically and died 1 year later.

Discussion

Operative mortality in large series of parsagittal and falx meningiomas were reported to be 3.7 − 16 % [7,12,13,15,17,26]. In the series of Hoessly and Olivercrona in 1955, it was 12.3%. Logue's series in 1975 had a surgical mortality rate of 3.7%. It decreased steadily as surgical techniques evolved. Operative mortality decreased to 2.6 % in our series. Postoperative cerebral edema was the most frequent cause of death in older series accounting for 10 out of 34 postoperative deaths in Hoessly and Olivecrona's series[15], 4 out of 16 in Gautier−Smith's series[12] and 9 out of 25 in Giombini's series[13]. There were no mortalities in our series related to this complication. The mechanism of severe brain edema after resection of meningioma is still controversial. Benoist analyzed 177

operated cases of parasagittal meningioma in view of this complication and suggested that damage to the venous system and location of the tumor may be contributory factors to the development and severity of postoperative brain eaema[2]. Microsurgical technique contributed to provide precise dissection of the tumor. Carbodioxide(CO_2) laser in recent cases made it possible to remove tissue without mechanical distortion. This is useful to excise the tumors, particularly the hard, fibrous and vascular ones. These technical refinement seems to reduce the mechanical damage to surrounding brain and venous structures reducing incidence of postoperative severe brain edema in our series. We encountered, however, severe, postoperative brain edema in 1 patient in whom a large right posterior third meningioma was rescted without complication (Grade II operation). The patient was treated with intensive medical therapies including high dose barbiturate therapy with continuous intracranial pressure monitoring. He subsequently recovered and was discharged with mild left sided weakness. Six months later, this patient showed new neurological deterioration. CT scan showed an enhancing leasion in the corpus callosum. This progressed and he died. Autopsy revealed no recurrence or regrowth of meningioma, but adrenoleukodystrophy in the corpus callosum and the white matter of the left hemisphere. The retrospective review of the preoperative MRI did not disclose the abnormality. It is interesting that marked perioperative brain swelling of unexpected degree was reported in cases of meningioma associated with coincidental glioma[8,9,21,23]. The gliomas were not recognized preoperatively and patients had severe brain swelling intra− or postoperatively. Although it occurs rarely, association of unrecognized coincidental intracranial lesions, as seen in our patients, can still be a cause of unexpected severe brain swelling in uncomplicated resection of meningioma.

In Giombini's series including 344 cases from 1947 to 1977, 23.9% of operative survivors had worsened neurological deficit and 17% had new ones[13]. In our series, neurological deficits worsened in 7.9% and 13.2% had new ones. In the Giombini's series only 9.9% of the patients were nerurologically intact at admission, while 42.1% were neulologically intact preoperatively in our series. Those patients presented with headache or seizure and the tumors were diagnosed accurately with CT or MRI before they produced neurological sings. Early diagnosis seemed to improve the immediate surgical outcome by virtue of smaller size of the tumor at surgery and a fine microsurgical resection reduced the damage of the surrounding structures.

In 3 referral series, it was reported that only 38−47% of the survivors were fully fit to return to work in 5 years after the operation and more than half of them were handicapped by permanent neurological dificit or by poor control of epilepsy[12,13,17]. The late outcome of our series was better than that of those series. Fourteen(58.3%) in the 24 survivors had no diasablilty and fully fit to return to work during the mean follow−up period of 6 years. Seven patients(29.2%) were independent in daily life. Only 3 patients (12.5%) needed constant medical care. The reduced operative morbidity seemed to reflect the improved late outcomes. All delayed deaths were related to recurrence of the tumors in our series.

Recurrence still seems to be the most ominous factor in terms of longterm prognosis. It has tendency to reduce the surival despite repeated operations. A parasagittal location was cited by Simpson as associated with the highest rate of recurrence and this appears to be due to unnoticed invasion of dural sinus and unsuspected spread across the falx[22]. The histological classification seems to be of little biological significance in relation to either the frequency of recurrence or the tendency to infiltrate[1,22]. Several surgical techniques have been proposed for radical resection maintaining or restoring the circulation in the sinus and its tributaries[3,14,16]. However, it is generally accepted that if a tumor invades the sinus in its posterior two thirds, it is safer to leave the sinus intact by resecting the tumor just lateral to the sinus and coagulating the sites of attachment. Reoperation for subsequent tumor recurrence in such an instance is accepted rather than risking serious morbidity or mortality related

to the sacrifice of the sinus. Recurrence rate in our series was 16.2% (6/37) which was not better than that reported in previous series[1,12,13,18,22,25,26]. Microsurgery and CT scan did not seem to be helpful in solving this problem. Five of our six recurrent cases had deteriorated after the second or third operation and four subsequently expired during the follow-up period. The biological behavior of meningiomas often cannot be predicted from the histopathological findings alone[6,24]. The role of postoperative radiation therapy in the management of partially resected meningiomas has not been clearly estabilised[4,10,25,26]. Recent advancement of cell kinetics studies seems to be promising in predicting the biological behavior of meningiomas[5,11,20]. This may lead to the better selection of treatment modalities in individual cases and improve the prognosis of patients with supratentorial midline meningiomas.

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