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Clinical features and surgical management of intracranial meningiomas in the elderly

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Abstract. Meningioma accounts for ~25% of all primary intracranial neoplasms and the incidence increases with age. Prvios population-based studies demonstrated that the annual incidence of intracranial meningiomas was 1.2-3.1/100,000 population. In particular, the incidence of this disease among the elderly is high. Recently, increased life expectancy and greater use of diagnostic radiological imaging led to an increased incidence in the diagnosis of intracranial meningiomas, both symptomatic and asymptomatic, in the elderly. Thus, neurosurgeons may be increasingly confronted with the management of intracranial meningiomas in the elderly. In practice, it is often difficult for physicians to determine whether traditional surgical resection is the optimal management strategy for intracranial meningiomas in the elderly. However, reported clinical studies about the outcome of surgical resection of intracranial meningiomas in the elderly are limited. Increased risk of mortality and morbidity associated with surgical treatment for intracranial meningiomas in the elderly compared with younger patients have been controversial. In the present study, the clinical features of intracranial meningiomas in 70 consecutive intracranial meningioma patients that underwent surgical treatment at the affiliated hospital of University of Occupational and Environmental Health between 2007 and 2013 were assessed. In addition, patient selection and surgical management of intracranial meningioma in elderly patients was discussed. Preoperative factors, including symptoms, tumor location, tumor size, Karnofsky Performance Scale (KPS) score and American Society of Anesthesiology (ASA) score, and postoperative factors, including pathological diagnosis, tumor proliferation index (Ki-67), resection rate (Simpson grade), length of hospital stay and discharge destination were retrospectively analyzed in patients aged ≥75 years (n=16; elderly group) and <75 years (n=54; younger group). Outcomes were assessed 6 months after surgery. Multivariate logistic regression revealed that tumor resection rate (Simpson grade III-V) was an important predictor of surgical complications (odds ratio, 5.662; 95% confidence interval, 1.323-24.236; P=0.0194). Perioperative morbidity was not correlated with age (>75 years), tumor location, tumor size, KPS score or ASA score. Thus, the present study indicated that age is not associated with surgical outcome in elderly meningioma patients. Regardless of patient age, the decision to perform surgical resection should be made on an individual basis wherein tumor characteristics and the general health of the patient are considered.

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Abbreviations: ASA, American Society of Anesthesiology; CT, computed tomography; KPS, Karnofsky performance scale; MRI, magnetic resonance imaging; WHO, World Health Organization

Key words: meningioma, geriatric, skull base surgery, craniotomy

Introduction

Meningioma accounts for ~25% of all primary intracranial neoplasms, increasing to 40% if autopsy data are included, indicating that a number of tumors remain clinically silent (1,2). The rising incidence of this tumor with age, in addition to higher life expectancy and more frequent use of diagnostic imaging, has resulted in increased diagnosis of meningioma in the elderly (1). In particular, brain screening with computed tomography (CT) and magnetic resonance imaging (MRI) is easily performed for nonspecific complaints and 'neurological checkups' are performed frequently in Japan (3). Thus, an increasing number of intracranial meningiomas are identified incidentally (4,5). However, few studies have reported the outcome of surgical resection of intracranial meningiomas in the elderly (6-10). Clinically, it is often difficult for physicians to determine whether traditional surgical resection is the optimal management strategy for meningioma in elderly patients: Due to their aging physiology and multiple comorbidities, elderly patients are potentially at risk of unexpected or even life-threatening surgical complications (7,8). Recent studies reported an increased risk of mortality and morbidity in older patients who underwent surgical treatment for intracranial meningioma (1,11,12), whereas other studies have demonstrated similar mortality and morbidity rates in old and young patients (8,13,14). Thus, patient selection and optimal treatment strategies for intracranial meningiomas in the elderly, which must consider patient lifestyle, survival benefits vs. side effects and the potential complications of surgery, including neurological deficits, continue to be debated (6,7,10,15). To standardize the surgical indications for intracranial meningiomas in the elderly, a number of studies have proposed grading systems, which include the clinical-radiological grading system (CRGS) (15), the geriatric scoring system (GSS) (16), Karnofsky performance scale (KPS) score, the American Society of Anesthesiology (ASA) score and the Location of Tumor and Peritumoral Edema grading system (SKALE) (17).

In the present study, the clinical features of intracranial meningiomas in elderly patients who underwent surgical treatment at the affiliated hospital of University of Occupational and Environmental Health (Kitakyushu, Japan) were assessed, and patient selection and the surgical management of intracranial meningioma in the elderly was discussed.

Patients and methods

This study was approved by the institutional review board of the University of Occupational and Environmental Health. Patient informed consent was waived due to the retrospective nature of the study. A total of 70 consecutive patients with intracranial meningioma who underwent craniotomy for resection of meningiomas between April 2007 and December 2013 were included. All patients were newly diagnosed with intracranial meningiomas. Recurrent cases, previous treatment of the brain with radiotherapy, and patients under 18 years of age were excluded from the study. The clinical diagnosis and treatment decision for all patients were based on the results of CT and MRI. Surgery was indicated for symptomatic patients, as well as asymptomatic patients that exhibited evidence of tumor progression on CT and/or MRI. Patients with no history of epileptic seizures, with the exception of those with posterior fossa tumors, were administered prophylactic anticonvulsant therapy (valproate, 600-800 mg/day or carbamazepine, 100-200 mg/day) for 2-4 weeks, and this treatment was prolonged for those with a history of epileptic seizures for ≥2 years. During the surgical procedures, a neuronavigation system (Kolibri; BrainLAB, Heimstetten, Germany) and an electrophysiological monitoring system (Neuromaster MEE-1216; Nihon Kohden Corporation, Tokyo, Japan) were used for microsurgical tumor resection. All patients received postoperative care in the intensive care unit at the University of Occupational and Environmental Health and rehabilitation therapy commenced on the first postoperative day.

Patient data was obtained by reviewing admission, surgical and anesthesia records, and patients' postoperative status was determined by reviewing outpatient clinical charts. The following patient data were collected: Age at diagnosis, gender, preoperative factors (patient symptoms, tumor location, maximum tumor size, peritumoral brain edema, KPS score and ASA score), and postoperative factors [pathological diagnosis, tumor proliferation index (Ki-67), tumor resection rate (Simpson grade), length of hospital stay and discharge destinations]. Patient outcomes were assessed 6 months after surgery. Patient data was then retrospectively compared between patients aged ≥75 years (n=16; elderly group) and those aged <75 years (n=54; younger group). Tumor location was divided into four groups: Convexity, falx, parasagittal and skull base. The maximum tumor size was measured on a contrast-enhanced T1-weighted image prior to surgery. Peritumoral brain edema was measured on preoperative T2-weight images, as described previously (17). Briefly, severe brain edema was defined when the ratio of maximum diameter of edema to the maximum diameter of the tumor was >1. Moderate brain edema was defined when this ratio was ≤1. Tumor resection rate was determined according to the Simpson grade (18) and tumors were pathologically graded according to the World Health Organization (WHO) classification (19). In addition, proposed grading scoring systems, including CRGS, GSS, and SKALE, were used to calculate scores for each patient using admission data, according to previous studies (9,15,17) and the correlation between these scores and surgical outcomes was assessed.

Statistical analysis. Differences in perioperative characteristics between the elderly and younger groups were compared using an unpaired *t*-test for binomial data and the Fisher exact test and Mann-Whitney U test were used for the comparison of nonparametric data. Multiple logistic regression analysis was performed to determine the association between the various risk factors for perioperative surgical complications [age (≥75 years), tumor location (skull base), maximum tumor size (≥5 cm diameter), preoperative KPS (≥70%) and tumor resection rate (Simpson grade, ≥III)]. Odds ratios and 95% confidence intervals were calculated for each risk factor. Similarly, risk factors for surgical complications, including proposed grading scoring systems, were evaluated by multiple logistic analyses. $P<0.05$ was considered to indicate a statistically significant difference. All statistical analyses were performed using StatView 5.0 statistical software (SAS Institute, Cary, NC, USA).

Results

Patients. Patient characteristics, preoperative factors and outcomes are shown in Table I. The mean (±standard deviation) ages of the elderly and younger patient groups were 81.1±5.3 years (range, 75-92 years) and 60.0±9.6 years (range, 35-73 years), respectively. The elderly patient group consisted of 4 male and 12 female patients, while the younger group consisted of 10 males and 44 females. Elderly patients most frequently presented with dementia as their initial symptom (31.3%), however, this was rare in the younger patient group (3.7%). Younger patients most commonly presented with visual disturbances (20.4%) and cranial nerve disturbances (20.4%). A total of 19 patients (35.2%) in the younger group were asymptomatic compared with 1 patient (6.3%) in the elderly group.

Preoperative KPS scores were significantly lower in the elderly group compared with the younger group ($P<0.0001$). Similarly, preoperative ASA scores were also significantly lower in the elderly group than the younger group ($P=0.0108$). Regarding tumor location, parasagittal meningiomas were the most common in elderly patients (37.5%), however, only 1 case of parasagittal meningioma was observed in the younger patient group (1.9%). The majority of tumors in younger patients were located at the skull base (70.3%). Notably, tumor size in the elderly group was significantly

Table I. Clinicopathological characteristics, perioperative factors and outcome of 70 intracranial meningioma patients.

Parameter	Elderly patient group, n (%)	Younger patient group, n (%)	P-value
Age, years			<0.0001
Mean ± SD	81.1±5.3	60.0±9.6	
Range	75-92	35-73	
Gender			0.7226
Male	4 (25.0)	10 (18.5)	
Female	12 (75.0)	44 (81.5)	
Symptoms			
Visual disturbances	2 (12.5)	11 (20.4)	
Cranial nerves[a]	2 (12.5)	11 (20.4)	
Headache	1 (6.3)	3 (5.6)	
Dementia	5 (31.3)	2 (3.7)	
Hemiparesis	3 (18.8)	2 (3.7)	
Ataxia	2 (12.5)	4 (7.4)	
Epilepsy	0 (0.0)	2 (3.7)	
Asymptomatic	1 (6.3)	19 (35.2)	
Preoperative KPS, %			<0.0001
≥80	9 (56.2)	52 (96.2)	
60-70	1 (6.3)	1 (1.9)	
<50	6 (37.5)	1 (1.9)	
Preoperative ASA score			0.0108
Class 1	1 (6.3)	15 (27.7)	
Class 2	12 (75)	38 (70.4)	
Class 3	3 (18.7)	1 (1.9)	
Class 4-5	0 (0.0)	0 (0.0)	
Tumor location			0.0316
Convexity	4 (25.0)	9 (16.7)	
Falx	1 (6.3)	6 (11.1)	
Parasagittal	6 (37.5)	1 (1.9)	
Skull base	5 (31.2)	38 (70.3)	
Maximum tumor size, cm			0.0004
Mean ± SD	50.1±13.3	34.9±14.7	
Peritumoral edema[b]			0.0001
None	3 (18.8)	37 (68.5)	
Moderate	8 (50.0)	15 (27.8)	
Severe	5 (31.2)	2 (3.7)	
Pathological diagnosis			0.0147
Meningothelial	6 (37.5)	41 (75.9)	
Fibrous	3 (18.8)	0 (0.0)	
Transitional	0 (0.0)	3 (5.6)	
Psammomatous	5 (31.2)	8 (14.8)	
Other[b]	2 (12.5)	2 (3.7)	
Ki-67, %			0.0336
Mean ± SD	2.3±2.5	1.4±1.0	
Simpson's grade			0.0792
I	6 (37.5)	15 (27.8)	
II	8 (50.0)	19 (35.1)	
III	0 (0.0)	4 (7.4)	
IV	2 (12.5)	15 (27.8)	
V	0 (0.0)	1 (1.9)	
Length of hospital stay, days			0.5823

Table I. Continued.

Parameter	Elderly patient group, n (%)	Younger patient group, n (%)	P-value
Mean ± SD	25.7±8.7	23.6±14.1	
Median	25	17	
Discharge destination			0.0420
Home	11 (68.8)	49 (90.7)	
Rehabilitation Center	5 (31.2)	5 (9.3)	
Postoperative mortalities[c]	0 (0.0)	0 (0.0)	
Postoperative complications			0.1641
Cranial nerve palsy	1 (6.3)	7 (13.0)	
Hemiparesis	0 (0.0)	3 (5.6)	
Speech disturbance	0 (0.0)	1 (1.9)	
Wound infection	0 (0.0)	2 (3.7)	
None	15 (93.8)	41 (75.9)	

Elderly patient group (n=16). Younger patient group (n=54). [a]Cranial nerve disturbances (excluding the optic nerves): 2 cases of trigeminal neuralgia in the elderly patients, and 2 cases of anosmia, 5 cases of trigeminal neuralgia and 3 cases of hearing disturbance in younger patients. One case demonstrated hemifacial palsy with ipsilateral hearing disturbance in a young patient. [b]Criteria based on Location of Tumor, and Peritumoral Edema. Angiomatous and atypical meningioma in elderly patients, while angiomatous and clear cell in younger patients were observed respectively. [c]Determined 6 months after surgery. SD, standard deviation; KPS, Karnofsky performance scale; ASA, American Society of Anesthesiology.

Table II. Multivariate logistic regression analysis of factors associated with surgical complications.

Parameter	Surgical complication OR	95% CI	P-value
Age (≥75 years)	0.265	0.017-4.071	0.3406
Tumor location (skull base)	1.504	0.244-9.274	0.6598
Maximum tumor size (≥5 cm)	4.507	0.793-25.603	0.0893
Preoperative KPS (≤70%)	0.814	0.050-13.311	0.8854
Severe peritumoral edema	0.857	0.059-12.474	0.9103
Simpson's grade (III-V)	5.680	1.321-24.420	0.0196

OR, odds ratio; CI, confidence interval; KPS, Karnofsky performance scale.

larger than that in the younger group (P=0.008). In addition, peritumoral brain edema was significantly more severe in the elderly group when compared with the younger group (P=0.0001; Table I).

Pathology. Pathologically, certain differences were observed between the two groups. Elderly patients frequently presented with meningothelial (37.5%) and psammomatous (31.2%) tumor types with a significantly higher proliferation index (Ki-67) than the younger group (P=0.05). In addition, 1 meningioma (WHO grade II; atypical type) case (6.3%) was observed in the elderly group. By contrast, the majority of meningiomas in the younger group were classified as the meningothelial type (75.9%). One meningioma case (WHO grade II; clear cell) was observed in the younger patient group, the incidence was low (1.9%) compared with that in the elderly patient group (Table I). However, no significant difference in the incidence of meningiomas was identified between the groups (P=0.4075).

Surgery and outcome. Gross total resection (Simpson grade I + II) was performed in 87.5 and 62.9% of the patients in the elderly and younger groups, respectively. No significant difference in the tumor resection rate was identified between the groups (P=0.0792). Although no significant difference in the length of hospital stay was identified between the groups, elderly patients were more likely to visit a rehabilitation center/convalescence hospital following discharge when compared with younger patients (P=0.042). No postoperative mortality was observed in either group.

Surgical complications in the elderly were limited to one case of facial palsy (7.7%). A total of 13 patients (25.6%) in the younger group exhibited surgical complications, which included the following: Cranial nerve palsy [oculomotor (n=1), trochlear (n=2), abducens (n=1), lower cranial (n=3)], hemiparesis (n=3), speech disturbance (n=1) and wound infection (n=2). One case of facial palsy in the elderly group, 2 cases of cranial palsy and 1 case of hemiparesis in the younger group persisted for >1 year after surgery. However, no significant

Table III. CRGS, GSS and SKALE scores of 70 intracranial meningioma patients according to clinicopathological factors.

A, CRGS score

	CRGS score		
Clinicopathological factor	1, n (%)	2, n (%)	3, n (%)
Size of tumor	8 (11)	24 (34)	38 (55)
Location of lesion	42 (60)	6 (9)	22 (31)
Presence of edema	15 (21)	15 (21)	40 (58)
Neurological condition	2 (3)	48 (69)	20 (28)
Concomitant disease	4 (6)	46 (66)	20 (28)
KPS score	7 (10)	25 (36)	38 (54)

B, GSS score

	GSS score		
Clinicopathological factor	1, n (%)	2, n (%)	3, n (%)
Tumor size	18 (26)	25 (36)	27 (38)
Neurological deficit	47 (67)	2 (3)	21 (30)
KPS score	7 (10)	25 (36)	38 (54)
Tumor location	13 (19)	17 (24)	40 (57)
Peritumoral edema	15 (21)	15 (21)	40 (58)
Diabetes mellitus	1 (1)	4 (6)	65 (93)
Hypertension	0 (0)	38 (54)	32 (46)
Pulmonary disease	0 (0)	4 (6)	66 (94)

C, SKALE score

	SKALE score		
Clinicopathological factor	0, n (%)	2, n (%)	4, n (%)
Gender	14 (20)	56 (80)	-
KPS score	7 (10)	12 (17)	51 (73)
ASA score	0 (0)	3 (4)	67 (96)
Tumor location	47 (67)	23 (33)	-
Presence of edema	7 (10)	23 (33)	40 (57)

CRGS, clinical-radiological grading system; GSS, geriatric grading system; SKALE, Location of Tumor, and Peritumoral Edema; KPS, Karnofsky performance scale; ASA, American Society of Anesthesiology.

difference in the incidence of surgical complications was identified between the two groups (P=0.1641). Among the 21 cases of Simpson grade III-IV meningiomas, 19 cases (90%) were skull base lesions and 2 cases (10%) were falx lesions. Among these, surgical complications affected 9 cases, including 6 cases of cranial palsy, 2 cases of hemiparesis and 1 case of speech disturbance. The 6 cases of cranial palsy were associated with manipulation of the cranial nerve, which was encased within or had adhered to tumors during the surgery. One case of hemiparesis and 1 case of speech disturbance were associated with postoperative brain edema in young patients. One case of hemiparesis was associated with postoperative cerebral infarction in the area of the lenticulostriate artery that was encased within the tumor. No cases of symptomatic intracavitary hematoma were observed following surgery.

Among the 2 cases of Simpson grade III-IV meningiomas in the elderly group, 1 patient developed postoperative facial palsy due to nerve manipulation during surgery. Multivariate logistic regression analysis identified a significant association between Simpson grade (III-V) and surgical complications. For patients with meningiomas with a low resection rate (Simpson grade III-V), the risk of experiencing surgical complications was 5.662 times higher than that of patients with a higher resection rate (Simpson grade, I-II) tumors (odds ratio, 5.662,

Table IV. Multivariate logistic regression analysis of the association between proposed grading system scores and surgical complications.

Variables	Surgical complications OR	95% CI	P-value
Age (≥75 years)	0.107	0.007-1.527	0.0992
CRGS score	1.300	0.182-9.258	0.7935
GSS score	7.875	0.503-123.276	0.1414
SKALE score	2.690	0.040-179.157	0.6441

CI, confidence interval; CRGS, clinical-radiological grading system; GSS, geriatric grading system; SKALE, Location of Tumor, and Peritumoral Edema; OR, odds ratio.

95% confidence interval, 1.323 to 24.236, P=0.0194) (Table II). Age, tumor location, maximum tumor size and preoperative KPS score were not associated with surgical complications.

CRGS, GSS, SKALE scores. Patient characteristics with corresponding CRGS, GSS and SKALE scores, are shown in Table III. Previous studies demonstrated that a poor outcome following surgical treatment for intracranial meningiomas in the elderly was associated with a score ≤9, ≤15 and ≤7 for the CRGS, GSS and SKALE, respectively (15-17). The cut-off point for postoperative complications was ≤9, ≤15, and ≤7 for CRGS, GSS, and SKALE, respectively (9,15,17). Multivariate logistic regression analysis revealed no significant associations between patient age (≥75 years), lower CRGS (≤9), GSS (≤15), and SKALE scores (≤7) and surgical complications (P=0.0992, P=0.7935, P=0.1414 and P=0.6441, respectively) (Table IV). In addition, among elderly patients (≥75 years), multivariate logistic regression analysis also revealed no significant difference between lower CRGS, GSS, and SKALE scores and surgical complications (P=0.9797, P>0.9999 and P=0.9883, respectively).

A case of left frontal convexity meningioma in elderly. An 87-year-old healthy and independent woman consulted her local hospital for an examination of a slight hearing disturbance, and a brain tumor was incidentally detected on a CT scan in November 2009. Therefore, the patient consulted the affiliated hospital of University of Occupational and Environmental Health. Neurological examination revealed no deficit. MRI demonstrated an enhanced extra-axial mass without peritumoral brain edema, corresponding to a parasagittal meningioma (Fig. 1A-C). Conservative treatment was selected due to the asymptomatic nature of the meningioma and the age of the patient. Thus, the patient was subjected to close observation using MRI without prophylactic anticonvulsant therapy. However, the patient discontinued undergoing follow-up MRI examinations 1 year later. Two years after diagnosis, the patient's condition deteriorated, and she consulted the affiliated hospital of University of Occupational and Environmental Health again in March 2011 with the assistance of her family, using a wheelchair. The patient presented with severe dementia and mild right hemiparesis (KPS, 20%; ASA score, 3). The patient's CRGS, GSS and SKALE scores were 10, 13 and 8, respectively. MRI revealed tumor progression with peritumoral brain edema (Fig. 1D-F). Subsequently, the patient underwent gross total resection of the tumor (Simpson grade II) without any surgical complications (Fig. 2). The pathological diagnosis was transitional meningioma (WHO grade I) (Ki-67, 2%). Following surgery, the patient's condition gradually improved and she was able to walk at the time of discharge. Follow-up MRI examination 1 year after surgery revealed no evidence of tumor recurrence (Fig. 2A-C) and a KPS score of 90%.

Discussion

Based on the results of previous autopsy studies, intracranial meningioma is likely to become an increasingly common disease in the elderly population (20-22). The annual incidence of intracranial meningioma among the elderly is estimated to be 8.4/100,000 persons in Manitoba, Canada (23) compared with 1.2-3.1/100,000 persons per year in the general population of Canada (23), USA (24), United Kingdom (25) and Japan (4), as assessed by epidemiological studies. As a result, neurosurgeons are increasingly confronted with the issue of intracranial meningioma management in the elderly. Surgical treatment of intracranial meningiomas in the elderly may be performed, depending on the patient's age and physiology, with consideration of the technical and ethical issues. However, the risk of surgical treatment must be balanced against the morbidity due to tumor growth that is associated with a conservative treatment.

Previous studies have investigated the natural history of intracranial meningiomas (26-30). The growth rate of intracranial meningiomas has been reported as 2.4-5.3 mm per year (27-29). Other studies have reported that hyperintensity on T2-weighted imaging, a non-skull base location and the absence of calcification on imaging are considered positive indicators of tumor growth in intracranial meningiomas (30,31). In addition, a non-skull base location and the absence of calcification correlate with a high tumor proliferation index (MIB-1) in intracranial meningiomas (32-35). To determine the MIB-1 staining index, the number of cells stained positively with MIB-1 and the total number of cells were counted in several representative fields containing >1,000 cells, and the ratio was defined as the MIB-1 staining index. Similarly, in the present study, it was demonstrated that intracranial meningiomas in elderly patients frequently exhibited a non-skull base location, significantly large tumor size and a high proliferation index (Ki-67) when compared with younger meningioma patients. Furthermore, peritumoral edema in intracranial meningiomas was more severe in elderly patients than younger patients. By contrast, previous studies have reported that untreated meningiomas in elderly patients were associated with a significantly lower incidence of tumor growth compared with that in younger patients (29,31,36).

Conservative treatment is usually recommended for asymptomatic meningiomas in the elderly. However, the Brain Tumor Registry of Japan reported that the incidence of surgical WHO grade II and III meningioma cases is 13.3 and 9.4% in elderly (≥75 years old) and younger patients (<75 years old), respectively (37). The present study demonstrated that

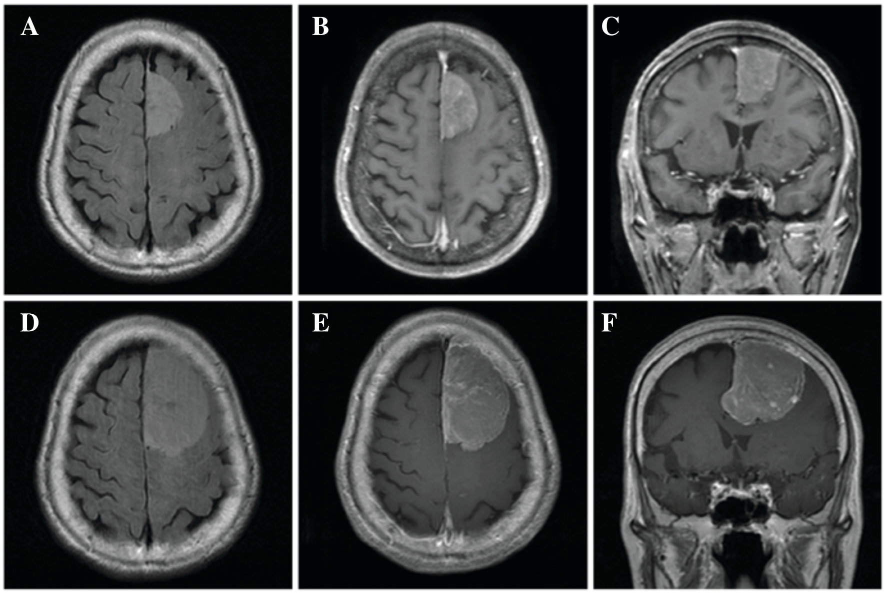

Figure 1. Representative case. (A) Axial fluid-attenuated inversion recovery MRI image and (B) axial and (C) coronal MRI performed at initial examination revealed an enhanced extra-axial mass without peritumoral brain edema. (D) Axial fluid-attenuated inversion recovery MRI image and (E) axial and (F) coronal MRI performed 2 years after diagnosis. MRI revealed evident tumor growth with peritumoral brain edema. MRI, magnetic resonance imaging.

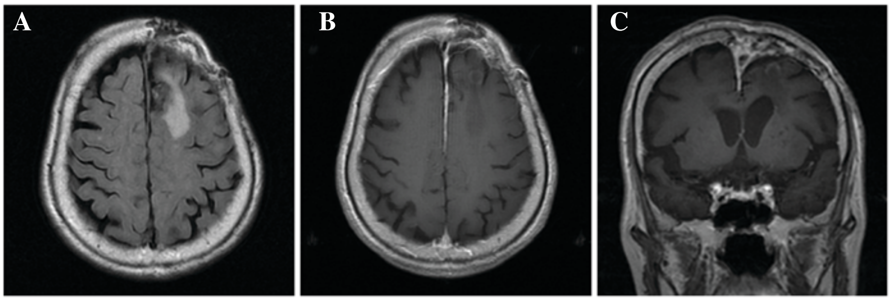

Figure 2. Follow-up magnetic resonance imaging performed 1 year after surgery. (A) Axial view of fluid-attenuated inversion recovery images, (B) axial and (C) coronal views of a contrast-enhanced T1-weighted images. No tumor recurrence was identified.

meningiomas in the elderly exhibit significant histological variations and a higher incidence of WHO grade II (6.5%) meningiomas when compared with younger meningioma patients. Taken together, these results indicate that surgically treated cases of intracranial meningioma in elderly patients may be biologically different when compared with untreated cases. Therefore, it is suggested that not only symptomatic tumors, but also asymptomatic cases that exhibit tumor growth during follow-up, should be considered for surgical treatment.

Whether there is an increased surgical risk for meningioma in elderly patients remains controversial (6,7,10,11,17). In the present study, the 1-year postoperative mortality rate of meningioma patients was 0% and the rate of postoperative complications in elderly patients was 7.7%. Multivariate logistic regression analysis indicated that the resection rate (Simpson grade III-V) was an important predictor of postoperative complications. By contrast, surgical complications did not correlate with age (>75 years), tumor location (skull base), tumor size (>5 cm), preoperative KPS score (≤70%) or preoperative ASA score (>class 3). Among the Simpson grade III-IV meningioma cases, surgical complications were observed in only 9 cases. One case was observed in the elderly patient group, whereby a facial nerve was encased in perto-clival meningioma. These complications were the result of surgical procedures, including nerve manipulation, postoperative brain edema and postoperative cerebral infarction due to brain retraction and coagulation of perforating arteries. No cases exhibited critical physical complications, such as severe cardiopulmonary dysfunction. Regardless of patient age, surgical difficulties during tumor resection in intracranial meningiomas may lead to postoperative complications and consequently result in a low rate of tumor resection (Simpson grade III-IV).

Previous studies have reported that the 30 day postoperative mortality rate is 0-10.8% in elderly meningioma patients (10,15,17,38). A recent prospective study of surgical resection of intracranial meningiomas reported that elderly patients (>70 years) exhibited significantly higher 30-day postoperative mortality rates (12.0%) than younger patients (4.6%) (6). In addition, multiple regression analysis identified age (>70 years), functional health status (including ASA score), preoperative disseminated cancer and tumor location (infratentorial) as important predictors of 30-day postoperative mortality (6). In particular, the risk of mortality in elderly patients (>70 years) was 3 times higher than that of younger patients (6). By contrast, a recent systematic meta-analysis indicated that the 1-year mortality rate following meningioma resection in elderly patients was 6-16% compared with 2-18% in untreated cohorts (7,39,40). In addition, the survival of elderly patients following meningioma resection was similar to that of the general population (7,39,40).

In a previous study, age was not an independent factor for predicting surgical outcome (7,10,15); in the present study it was demonstrated that age was not associated with increased surgical risk in elderly patients with intracranial meningioma, which was consistent with previous studies (7,10,15). Several studies have assessed predictors for surgical outcome in elderly meningioma patients using CRGS, GSS and SKALE scoring systems that include tumor size, gender, KPS score, ASA score, tumor location, peritumoral edema and concomitant disease (9,10,16). The CRGS, GSS and SKALE scoring systems have been proposed for use in patients aged over 70, 65 and 80 years, respectively. Although these scores may provide useful information for determining the optimal treatment for intracranial meningiomas in the elderly, in actual practice, the difficulties encountered during surgery for intracranial meningiomas (including tumor vascularity, venous drainage, tumor attachment, involvement of cranial nerves and degree of brain stem adhesion or compression) and the surgeon's experience are more likely to affect the surgical outcome (40-42).

A previous study investigated postoperative outcomes in intracranial meningiomas, extending the CRGS and SKALE scoring systems to younger patients (≥65 years old) (10). However, they were unable to reproduce the utility of the two proposed grading systems (17). The present study also evaluated surgical complications, using these scoring systems, including GSS. Similarly, no correlation was identified between these scoring systems and surgical complications in all patients, including the elderly. In the present study, only the tumor resection rate was associated with postoperative complications. Thus, the difficulty of meningioma resection may affect the tumor resection rate and consequently lead to postoperative complications. Taken together, for the surgical management of meningioma in the elderly, individual patient health status and characteristics of the tumor should be considered rather than patient age.

An important limitation of this study is that no neuropsychological evaluations were performed. In this study, 5 patients presented with dementia as the initial symptom. The incidence of large tumors, convexity, and falx meningioma was increased in the elderly when compared with younger patients. In elderly intracranial meningioma patients that develop dementia, it is difficult to determine whether the disease is a result of meningiomas or the natural aging process. Thus, prospective studies of surgical management of intracranial meningiomas in the elderly which investigate neuropsychological function, are required.

Neurosurgeons may be increasingly confronted with the issue of intracranial meningioma management in the elderly, which in the majority of cases is treated conservatively. Although the sample number was limited in the present study, it was demonstrated that only tumor resection rate, not patient age, was associated with surgical outcome. If tumors in elderly patients are symptomatic, or asymptomatic with tumor growth during follow-up, specific treatment, including surgical resection, is required. The present study demonstrated that regardless of patient age, the decision to perform surgical resection should be made on an individual basis whereby tumor characteristics and the general health of the patient are considered.

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