

## Surgical management of spinal meningiomas: A retrospective case analysis based on preoperative surgical grade

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### Abstract

**Background:** Although spinal meningiomas respond favorably to surgical excision, their surgical management is impacted by several factors. This study utilized a surgery-based grading system to discuss the optimal surgical strategy.

**Methods:** Twenty-three consecutive patients who underwent surgery for spinal meningiomas were included in this retrospective study. The patients' neurological condition was assessed using the modified McCormick functional schema (mMFS) and sensory pain scale (SPS), and tumor removal was assessed using Simpson grade. Major factors contributing to surgical difficulty included; tumor size, extent/severity of cord compression, location of tumor attachment, spinal level, and anatomical relationships plus tumor extending in a dumbbell shape and local postoperative recurrence.

**Results:** Fifteen cases were classified as ventral attachment (65.2%). There were two dumbbell-shaped tumors and three local recurrences at the primary site. Simpson grade 1 or 2 resections were performed in 18 of 20 cases (90%) with preoperative surgical grades 0 to 3. Simpson grade 4 resections were achieved in all three cases with preoperative surgical grades 4 to 5. Overall neurological assessment after surgery revealed the satisfactory or acceptable recovery on mMFS and SPS analysis.

**Conclusions:** Lower preoperative grade yielded better results, while the higher the preoperative grade, the more likely tumor was insufficiently removed. A preoperative surgical grading system appeared to be helpful when considering the surgical strategy. Ventral meningiomas could be safely resected via the posterolateral or lateral approach using technical modifications. Recurrent tumors, especially with ventral attachment, were hard to resolve, and primary surgery appears to be important.

**Key Words:** Recurrence, spinal extramedullary tumor, spinal meningioma, surgical outcome, ventral attachment

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## INTRODUCTION

Spinal meningiomas, common intradural spinal tumors, accounting for 25% of all spinal neoplasms.<sup>[14]</sup> As they are typically slow growing and benign, they respond favorably to surgical excision.<sup>[3,4,7,8]</sup> The goal of surgery is the safe and precise resection of the tumor (e.g. macroscopically complete tumor removal particularly in younger patients) with satisfactory/acceptable functional recovery and the preservation of spinal stability. The surgical management of spinal meningiomas is impacted by several factors; the patient’s neurological condition, tumor size, tumor location, spine level, or anatomical relationship with spinal cord. Notably, excision of recurrent spinal meningiomas is often formidable.<sup>[11,12]</sup> This study utilized a surgery-based grading system to retrospectively assess 23 patients undergoing the resection of spinal meningiomas. Specifically we focused on the requisite surgical strategy utilized to achieve safe and precise surgical tumor removal.

## MATERIALS AND METHODS

### Patients

In this retrospective review covering a 7-year period, 23 patients underwent the removal of spinal meningiomas. There were 8 males and 15 females averaging 60.3 years of age (range 21-84 years). Tumors were located as follows: craniovertebral junction to C2 (10 cases), subaxial cervical spine from C3 to C7 (4 cases), and thoracic spine (9 cases); lumbar tumors were excluded.

### Assessment of preoperative neurological status and postoperative resection (Simpson grade)

Patients’ neurological status was assessed utilizing the modified McCormick functional schema (mMFS) and sensory pain scale (SPS) before and after surgery [Table 1].<sup>[10,17-19]</sup> Patients were followed an average of 32.1 months (range 1-84 months). Tumor removal was graded using the Simpson grade for removal of meningiomas [Table 2], and the extent of excision was confirmed utilizing early postoperative magnetic resonance imaging (MRI) studies.<sup>[16]</sup>

### Proposed grading system

Major factors contributing to surgical difficulty included; tumor size, extent/severity of cord compression, location of tumor attachment, spinal level, and anatomical relationships with eloquent contiguous structures. Therefore, the authors developed a five point grading system to summarize the surgical difficulty involved with tumor resection. These included those listed above plus tumor extending in a dumbbell shape, and local postoperative recurrence [Table 3]. These findings were documented utilizing a computerized medical records system (EGMAIN-EX, Fujitsu Limited, Japan).

### Statistical analysis

Statistical comparisons between the two study groups were performed with Fisher’s exact test. JMP 9.0 (SAS

institute, Inc.) was used for statistical analysis in the present study. A  $P < 0.05$  was considered significant.

### Statement of ethics

The authors certify that all applicable institutional and governmental regulations concerning the ethical use of clinical data were followed in the present study. This comprehensive analysis of surgery-related outcomes

**Table 1: Modified McCormick functional schema and sensory pain scale**

Grade	Definition
1	Neurologically normal; mild focal deficit not significantly affecting limb function; mild spasticity or reflex abnormality; normal gait
2	Presence of sensorimotor deficit affecting function of involved limb; still functions and ambulates independently; mild gait difficulty
3	Presence of sensorimotor deficit affecting function of involved limb; still functions and ambulates independently; moderate gait difficulty
4	More severe neurological deficit; requires cane/brace for ambulation or significant bilateral upper-extremity impairment; may or may not function independently
5	Severe deficit; requires wheelchair or cane/brace w/bilateral upper-extremity impairment; usually not independent
1	No symptoms
2	Mild pain or dysesthesia, slightly impairing QOL
3	Moderate pain or dysesthesia, fairly impairing QOL
4	Severe pain or dysesthesia, significantly impairing QOL

QOL: Quality of life

**Table 2: Simpson grading system for removal of meningiomas**

Grade	Definition
1	Macroscopically complete removal with excision of dural attachment and abnormal bone
2	Macroscopically complete removal with endothermy coagulation (Bovie, or laser) of dural attachment
3	Macroscopically complete removal without resection or coagulation of its extradural extensions
4	Partial removal leaving intradural tumor <i>in situ</i>
5	Simple decompression with or without biopsy

**Table 3: Preoperative surgical grading system for spinal meningiomas**

MR Finding	Point assignment
Maximum tumor transverse diameter was longer than two-thirds of the spinal canal diameter	1
Degree of spinal cord compression: T2-weighted MR images with intramedullary high signal	1
Ventral tumor attachment to the dura mater (ventral half of the spinal canal)	1
Dumbbell tumor extension outside the neural foramen	1
Local tumor recurrence	1

MR: Magnetic resonance

was approved by the ethics committee of Osaka City University Graduate School of Medicine.

## RESULTS

In 17 of 23 cases (73.9%), the maximum tumor transverse diameter was clearly larger than two-thirds of the spinal canal diameter. Nine cases (39.1%) showed an intramedullary high signal of the spinal cord on T2-weighted MR images. Eight cases were classified as dorsal tumor attachment (34.8%), with the remaining 15 cases located ventrally (65.2%). There were two dumbbell-shaped tumors and three local recurrences at the primary site. Clinical summary of the patients are shown in Table 4.

### Surgical method

As our general principle, spinal meningiomas with dorsal attachment were resected utilizing a standard unilateral posterior approach. Those located ventrally, especially large tumors, were resected utilizing a posterolateral [Figures 1 and 2] (Video 1) or lateral approach [Figures 3 and 4] (Video 2) using technical modifications (e.g. a lateral oblique position, a unilateral partial facetectomy to preserve spinal stability, or spinal cord rotation technique with resection of the dentate ligament was employed).<sup>[1,5,9,15,21,22]</sup>

### Clinical relationship between preoperative surgical grade and tumor removal

The lower the preoperative surgical grade and the greater the extent of tumor removal; significantly more extensive tumor removal was achieved for the Low vs. High-grade groups (Fisher's exact test;  $P = 0.006$ ) [Table 5]. Simpson grade 1 or 2 resections

were performed in 18 of 20 cases (90%) with preoperative surgical grades 0 to 3. Simpson grade 4 resections were achieved in all three cases with preoperative surgical grades 4 to 5. The present study included three recurrent cases at the primary site (Cases 1, 6, 18). Although Simpson grade 2 resection was achieved in Case 6, Simpson grade 4 with partial resection was only achieved in the remaining two cases (Cases 1 and 18). The preoperative surgical grades of Cases 1 and 18 were grade 4 and 5, respectively.

### Postoperative functional preservation

Functional outcomes were assessed using mMFS and SPS 3 months after surgery (2 exceptions). Utilizing mMFS, 14 patients improved, 8 were unchanged, and 1 patient deteriorated. SPS analysis demonstrated that 12 patients improved, 9 unchanged, and 2 deteriorated.

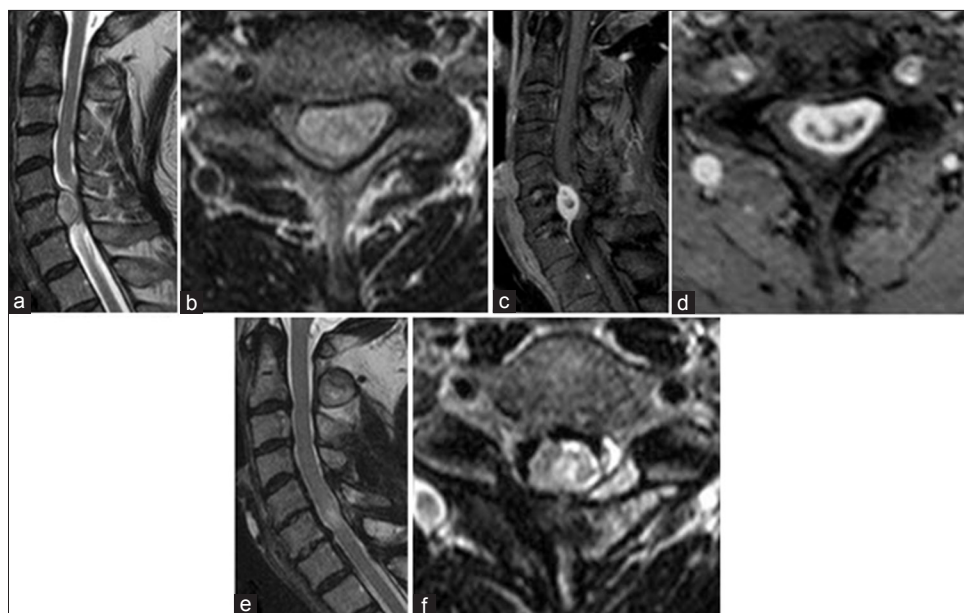
## DISCUSSION

In the present study, the surgical outcomes of 23

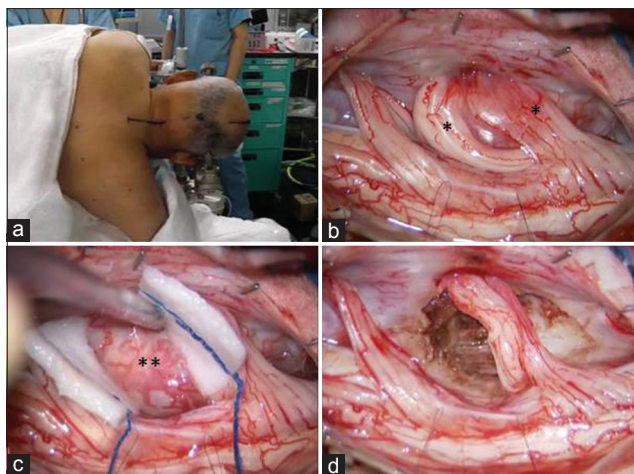
**Table 4: Clinical summary of the patients with spinal meningiomas analyzed in the present study**

Preoperative surgical grade	No. of patients	Spine level		
		CVJ to C2	C3 to C7	Thoracic
0	2	1	0	1
1	7	4	1	2
2	7	4	0	3
3	4	0	2	2
4	2	1	0	1
5	1	0	1	0

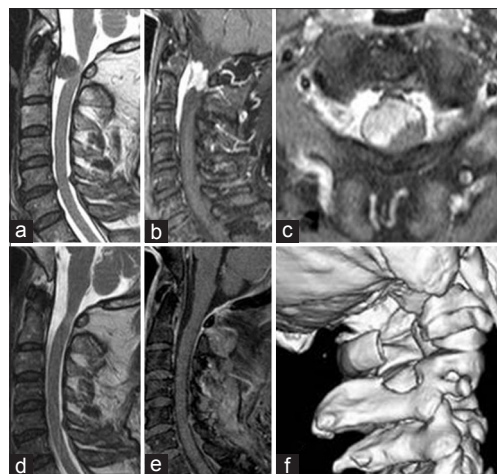
CVJ: Craniovertebral junction



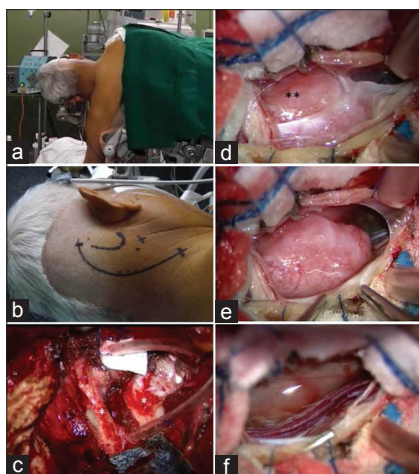
**Figure 1: Case 19, Preoperative surgical grade 3** Preoperative T2 (a, b) and enhanced T1-weighted (c, d) MR images of the cervical spine showing extramedullary tumor with ventral attachment compressing the spinal cord at the spinal level of C6. Postoperative T2-weighted (e, f) MR images showing satisfactory decompression of the spinal cord



**Figure 2: Case 19, Posterolateral approach** Intraoperative photographs showing that the patient was placed in the right lateral oblique position (a), and that the tumor was completely localized in the ventral canal compressing the spinal cord dorsally (b). The left C6 nerve roots (\*) were severely stretched by the tumor. The tumor (\*\*) was well exposed by posterolateral exposure (c). Total removal of the tumor with Simpson grade 1 showing satisfactory decompression of the spinal cord (d). Supplemental digital content of surgical video Patient 19 was provided



**Figure 3: Case 21, Preoperative surgical grade 3** Preoperative T2 (a) and enhanced T1-weighted (b, c) MR images of the cervical spine showing extramedullary tumor with ventral attachment compressing the spinal cord at the spinal level of C1. Postoperative T2 (d) and enhanced T1-weighted (e) MR images showing satisfactory decompression of the spinal cord. Postoperative CT showing unilateral partial laminectomy of C1-C2 (f)



**Figure 4: Case 21, Lateral approach** Intraoperative photographs showing that the patient was placed in the left lateral oblique position (a), and retroauricular skin incision was designed (b). Right unilateral exposure of C1-C2 (\*) was completed (c). The tumor (\*\*\*) was completely localized in the ventral canal compressing the spinal cord dorsally (d). The tumor was well exposed by lateral exposure (d). Total removal of the tumor with Simpson grade 2 showing satisfactory decompression of the spinal cord (e). Supplemental digital content of surgical video Patient 21 was provided

**Table 5: Simpson grade based on preoperative surgical grade**

Tumor grade	Simpson grade				
	1	2	3	4	5
Low					
0	1	1			
1		6	1		
2	3	3	1		
3	1	3			
High					
4				2	
5				1	

Kim *et al.* successfully removed 18 large ventral, intradural, extramedullary tumors using the posterior approach (conventional laminectomy).<sup>[6]</sup> Angevine *et al.* stated that most intradural ventral spinal lesions can be treated with contemporary microsurgical techniques, achieving long-term control/cure with preservation of neurological function.<sup>[1]</sup> However, posterior exposures required varying degrees of lateral bone resection, dentate ligament division, and gentle cord rotation; anterior approaches may still occasionally be necessary.

Although spinal meningiomas generally respond favorably to surgical excision and have a low recurrence rate, some reports have suggested high tumor recurrence rates in patients aged younger than 50 years at the time of surgery and in patients followed for long periods even after Simpson grade 2 resection.<sup>[2,13]</sup> King *et al.* reported their surgical results of 78 spinal meningioma cases that were operated on over 20 years at a single neurosurgical unit.<sup>[7]</sup> They showed that there was only one recurrence 14 years after the original surgery, and

consecutive patients with spinal meningiomas were retrospectively analyzed utilizing a unique preoperative surgical grading system; lower preoperative grades yielded better results, while the higher the preoperative grade, the more likely tumor was insufficiently removed. Furthermore, recurrent tumors with ventral attachment were the most difficult to treat.

A predominantly posterior approach is utilized to resect ventral, intradural, extramedullary spinal meningiomas.<sup>[1,6,20]</sup>

they concluded that excision of the dural base was unnecessary to achieve a low recurrence rate. The factors leading to recurrence after surgery have been discussed by various authors, and they include young age of the patient, subtotal resection of the lesion, calcification, extradural attachment, multiplicity of lesions, and anterior placement.<sup>[2,7,11,12,13]</sup> Cohen-Gadol *et al.* reviewed data obtained in a cohort of 40 patients aged less than 50 years with histologically confirmed spinal meningiomas.<sup>[2]</sup> They compared these data with those derived from a control cohort of 40 patients aged over 50 years in whom resection of spinal meningioma was performed over the same period. They reported a recurrence rate of 22% (9 of 40 patients) in the younger patient group as compared with 5% (2 of 40 patients) in the older control group, highlighting the aggressive nature of these benign neoplasms in younger patients. Nakamura *et al.* reported that 6 of their 19 cases (31.6%), who underwent Simpson grade 2 resection, required reoperation due to tumor recurrence with exacerbated neurological symptoms, although none of the 43 patients treated by Simpson grade 1 resection experienced tumor recurrence.<sup>[13]</sup> In most recurrent spinal meningiomas, the integrity of the arachnoid membrane is usually compromised, and the tumor may also invade the pial membrane of the spinal cord. In such cases, the dissection plane between the spinal cord and recurrent tumor is not clearly recognized, resulting in partial decompression of the spinal cord. Klekamp *et al.* suggested that en plaque and recurrent meningiomas remain surgical challenges, since infiltration of surrounding structures and associated arachnoid scarring may render complete resection difficult to achieve.<sup>[8]</sup>

In the present study, a simple, preoperative surgical grade for spinal meningiomas was proposed, and it appeared that a higher preoperative surgical grade was significantly associated with insufficient tumor removal, and a lower preoperative surgical grade also tended to result in better functional outcome. Recurrent tumors, especially with ventral attachment, were hard to resolve, and primary surgery appears to be important. However, there were several limitations in the present study. First of all, although the existence of adhesions between the spinal cord and meningiomas is one of the important determinants of surgical difficulty, it could not be evaluated using conventional MR images. Second, there was heterogeneity in the spinal level of the analyzed cases. The present study included relatively more cases involving the craniovertebral junction to C2 level compared with the published data. Finally, the follow-up period was quite short, and it is not possible to make conclusions with respect to long-term outcomes. Further studies of more cases with a longer follow-up period are absolutely necessary.

## CONCLUSIONS

Surgical outcomes of 23 consecutive patients with spinal meningiomas were retrospectively analyzed utilizing a unique preoperative surgical grading system; lower preoperative grade yielded better results, while the higher the preoperative grade, the more likely tumor was insufficiently removed. A preoperative surgical grading system appeared to be helpful when considering the surgical strategy. Ventral meningiomas could be resected via the posterolateral or lateral approach using technical modifications, although there may be some circumstances or situations where direct anterior access to the ventral spinal canal is required. Recurrent tumors, especially with ventral attachment, were hard to resolve, and primary surgery appears to be important.

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