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Kentaro Naito, Toru Yamagata, Hironori Arima, Toshihiro Takami

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Title:

Low Recurrence after Simpson Grade II Resection of Spinal Benign Meningiomas in a Single-Institute 10-Year Retrospective Study

Authors:

Kentaro Naito, MD¹ (7110ken622@med.osaka-cu.ac.jp)

Toru Yamagata, MD² (punchdrunkard830@yahoo.co.jp)

Hironori Arima, MD¹ (1997hiro@med.osaka-cu.ac.jp)

Toshihiro Takami, MD¹ (ttakami@med.osaka-cu.ac.jp)

Affiliations:

¹ Department of Neurosurgery, Osaka City University Graduate School of Medicine, 1-4-3 Asahi-machi, Abeno-ku, Osaka 545-8585, Japan

² Department of Neurosurgery, Osaka City General Hospital, 2-13-22 Miyakojima-hondori, Miyakojima-ku, Osaka 531-0021, Japan

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Address all correspondence to:

Toshihiro Takami, MD

Department of Neurosurgery, Osaka City University Graduate School of Medicine

1-4-3 Asahi-machi, Abeno-ku, Osaka 545-8585, Japan

Tel: +81-6-6645-3846

Fax: +81-6-6647-8065

E-mail: ttakami@med.osaka-cu.ac.jp

Abstract

The objective of this study was to more fully understand the optimal neurosurgical strategy for spinal benign meningiomas from a medium to long-term perspective. This retrospective study included a cohort of 35 patients with a diagnosis of spinal meningioma who were first operated at our institute over the past 10 years and followed-up for at least 2 years after surgery. The inclusion criterion for the study was the pathological diagnosis finally verified as benign meningioma of World Health Organization (WHO) grade 1. The average follow-up duration after surgery was 61.0 months. The location of the spinal meningioma was classified into ventral or dorsal type based on the operative video record and the preoperative MR images. The extent of resection of the spinal meningioma was carefully determined based on the Simpson grade. The average neurological condition was significantly improved at the final follow-up. Simpson grade I or II resection was achieved in 31 of 35 cases (88.6%). No Simpson grade I or II cases showed local recurrence during follow-up. Tumor recurrence was noted in 2 of 4 cases of Simpson grade IV resection. One case has been followed-up without any re-operation because of no neurological deterioration, and the other case underwent stereotactic radiosurgery. This study suggested that meticulous Simpson grade II resection of spinal benign meningiomas of WHO grade 1 may be good enough from a medium to long-term follow-up perspective, though longer follow-up is absolutely necessary.

1. Introduction

With regard to the recurrence rate long after surgery of spinal benign meningiomas of World Health Organization (WHO) grade 1, it has been suggested that Simpson grade I resection is desirable, and grade II resection may be insufficient.¹ However, Simpson grade I resection may carry a possible risk of surgery-related complications, especially for spinal meningiomas with ventral dural attachment. Simpson grade II resection may be good enough to avoid recurrence in the medium to long term after surgery.²⁻⁴ There is also some controversy regarding the surgical method or approach for spinal meningiomas with ventral dural attachment.⁵⁻⁹ The standard posterior approach for spinal meningiomas with ventral dural attachment would increase surgery-related complications, although it may be acceptable to safely resect them.

A consecutive case series of spinal meningiomas that were initially operated at our institute is presented. Although Simpson grade I resection was first considered whenever safely possible, especially for younger patients, Simpson grade II was considered in cases in which Simpson grade I resection was challenging or not safely possible. The objective of this study was to more fully understand the optimal neurosurgical strategy to manage spinal benign meningiomas from a medium to long-term perspective.

2. Methods

This single-institute, retrospective, observational study was approved by the ethics committee of Osaka City University Graduate School of Medicine (No. 2019-059).

2.1. Patient population

This retrospective study included a cohort of 35 patients with a diagnosis of spinal meningioma

who were initially operated at our institute over the past 10 years between April 2008 and March 2017 and followed-up for at least 2 years after surgery. The inclusion criterion for study entry was a final pathological diagnosis of benign meningioma of WHO grade 1, not atypical or anaplastic meningioma. Recurrent cases after the initial surgery at our or another institute were excluded from the study analysis. There were 10 males and 25 females (average age 62.8 years; range 23-85 years). Postoperative follow-up duration ranged from 24 to 138 months, with an average duration of 61.0 months. All patients underwent comprehensive radiological evaluation before surgery. Their clinical condition was assessed using the modified McCormick functional schema and a sensory pain scale (Table 1).^{7,8,10,11} The location of spinal meningioma was classified as ventral or dorsal type based on the operative video record and preoperative T1-weighted, enhanced MR images (Fig. 1). Ventral type was defined as the tumor attachment located completely ventral to the dentate ligament. The extent of resection of spinal meningioma was carefully assessed based on the operative video record and postoperative T1-weighted enhanced MR images in all cases and classified according to the 5 Simpson grades (Table 2).¹² All medical records were analyzed retrospectively using a computerized medical record system.

2.2. Selection of surgical approach

The surgical approach was determined at a neurosurgical board (Fig. 2). In cases of dorsal spinal meningiomas, a posterior unilateral approach was preferred. In cases of ventral spinal meningiomas except the lumbar spine, a posterolateral or lateral approach using the lateral oblique position was preferred.^{7,8} Microscopic resection of ventral meningiomas using the technique of spinal cord rotation was used instead of spinal fusion surgery to obtain a wide operative field. In cases of spinal meningiomas at the lumbar spine, a posterior unilateral

approach was selected.

2.3. Statistical analysis

All data are expressed as means $\pm$ standard deviation. Statistical comparisons between before and after surgery were performed using the Wilcoxon signed-rank test. JMP version 14.0 software (SAS Institute, Cary, NC) was used for all statistical analyses in the present study. Values of $p < 0.05$ were considered significant.

3. Results

3.1. Surgical data

A total of 35 operations were performed in 35 cases. No cases needed spine fusion surgery. A total of 12 cases were noted at the craniovertebral junction to C2 level, 4 cases at the cervical spine, 17 cases at the thoracic spine, and the remaining 2 cases at the lumbar spine. In 12 cases at the craniovertebral junction to C2 level, 10 cases were classified as ventral type, and 2 cases were classified as dorsal type. In 4 cases at the cervical spine, 3 cases were classified as ventral type, and 1 case was classified as dorsal type. In 17 cases at the thoracic spine, 4 cases were classified as ventral type, and 13 cases were classified as dorsal type. Two of all 35 cases showed dumbbell formation. The levels and locations of spinal meningiomas are summarized in Table 3. Simpson grade I or II resection was achieved in 31 of 35 cases (88.6%). Subtotal resection of Simpson grade IV was noted in the remaining 4 cases. The reasons for subtotal resection in these 4 cases were residual tumor in the hypoglossal canal in 2 cases, around the vertebral artery in 1 case at the craniovertebral junction, and in the extradural foramen in 1 case at the thoracic spine. Those tumors were left behind intentionally to avoid neurological deterioration or spine fusion

surgery. The extent of tumor resection is summarized in Figure 3.

3.2. Clinical outcome

The average grade on the modified McCormick functional schema before surgery was 2.6, and it improved significantly to 1.7 at the final follow-up. The average grade of the sensory pain scale before surgery was 2.4, and it improved significantly to 1.5 at the recent follow-up. Surgical outcomes are summarized in Figure 4.

3.3. Recurrence rate based on extent of tumor resection

None of the 31 cases of Simpson grade I or II demonstrated local recurrence during follow-up. Tumor recurrence was noted in 2 of 4 cases of subtotal resection of Simpson grade 4. One case has been followed-up without any reoperation because of no neurological deterioration, and the other case underwent stereotactic radiosurgery. The recurrence rate based on the extent of tumor resection is summarized in Table 4.

3.4. Illustrative case presentation

Case 1

A 70-year-old woman presented with a 1-year history of gait disturbance. Her ambulation was still independent, but the gait disturbance fairly impaired her activities of daily living. Neurological examination showed mild motor weakness and hyperreflexia of both lower extremities, with decreased sensation up to the cervical level. Preoperative T1-weighted enhanced MR sagittal images showed a tumor in the ventral part of the spinal canal at the craniovertebral junction (Fig. 5A). T2-weighted MR sagittal images showed that the spinal cord

was severely compressed by the tumor (Fig. 5B). The preoperative clinical grade was grade 2 on the modified McCormick functional schema and grade 4 on the sensory pain scale. The surgery went well with a posterolateral approach using the lateral oblique position (Supplemental video 1 of microsurgical resection of ventral spinal meningioma). Tumor resection was confirmed as Simpson grade II. After the surgery, the patient demonstrated significant improvement of her gait disturbance. MRI obtained 3 months after surgery showed complete resection of the tumor (Fig. 5C). The postoperative clinical grade was grade 1 on the modified McCormick functional schema and grade 2 on the sensory pain scale.

Case 2

A 74-year-old woman presented with a 2-year history of gait disturbance and urinary disturbance. Her ambulation was still independent, but the gait disturbance fairly impaired her activities of daily living. Neurological examination showed mild motor weakness and hyperreflexia of both lower extremities, with decreased sensation up to the Th5 level. Preoperative T1-weighted enhanced MR sagittal images showed a tumor in the ventral part of the spinal canal at the cervicothoracic junction (Fig. 6A). T2-weighted MR sagittal images showed that the spinal cord was severely compressed by the tumor (Fig. 6B). The preoperative clinical grade was grade 3 on the modified McCormick functional schema and grade 3 on the sensory pain scale. The surgery by the posterolateral approach using the lateral oblique position (Supplemental video 2 of microsurgical resection of ventral spinal meningioma) went well. Tumor resection was confirmed as Simpson grade II. After the surgery, the patient demonstrated significant improvement of the gait disturbance and urinary incontinence. MRI obtained 3 months after surgery showed complete resection of the tumor (Fig. 6C). The postoperative

clinical grade was grade 2 on the modified McCormick functional schema and grade 2 on the sensory pain scale.

4. Discussion

This single-institute, retrospective study focused on the middle to long-term surgical outcomes of spinal benign meningiomas of WHO grade 1. Simpson grade I or II resection was achieved in 31 of 35 cases (88.6%). Subtotal resection of Simpson grade IV was noted in the remaining 4 cases. The reasons for subtotal resection in these 4 cases were residual tumor in the hypoglossal canal in 2 cases, around the vertebral artery in 1 case, and in the extradural foramen in 1 case. These tumors were left behind intentionally. The functional outcome was good even in the spinal meningiomas of ventral type. None of the 31 cases of Simpson grade I or II demonstrated local recurrence during the average follow-up of 61.0 months. Tumor recurrence was noted in a total of 2 of 4 cases of subtotal resection of Simpson grade IV. One case has been followed-up without any reoperation because of no neurological deterioration, and the other case underwent stereotactic radiosurgery.

With regard to the recurrence rate long after surgery of spinal benign meningiomas of World Health Organization (WHO) grade 1, it has been suggested that Simpson grade I resection is desirable, and grade II resection may be insufficient.¹ Nakamura et al. analyzed the long-term outcomes of spinal meningiomas in 68 patients. They found a relatively high recurrence rate in patients who underwent Simpson grade II resection. Their histological examination of the resected dura mater showed that tumor invasion between the inner and outer layers of the resected dura mater was seen in 35%. They concluded that Simpson grade I resection should be selected whenever practical for younger patients. Yamamuro et al. examined the histological

features of the dural origin of spinal meningioma in 25 cases.¹³ They showed that 19 of the 25 cases (76%) of spinal meningiomas showed evidence of dural invasion, and 15 cases (60%) showed full-thickness invasion. These findings may suggest that Simpson grade I resection is theoretically appropriate for spinal meningiomas, especially in younger patients. Kim et al. retrospectively reviewed the clinical data of 21 patients who underwent Simpson grade I resection and 20 patients who underwent Simpson grade II resection for spinal meningiomas.¹⁴ A recurrence after Simpson grade II resection was noted in only 1 patient at 92 months after surgery. Maiti et al. retrospectively reviewed the clinical and radiological details of 38 cases of spinal meningiomas that were treated surgically between 2001 and 2015.¹⁵ Male sex and tumors with the dural tail sign were associated with an increased risk of recurrence at a mean follow-up of 51.2 months. Ventral or ventrolateral location of the tumor, large size, signal change on preoperative T2-weighted MR images, and poor preoperative functional status were associated with a poor functional outcome at 1-year postoperatively. Raco et al. conducted a retrospective review of 173 cases of spinal meningiomas that were treated surgically from 1976 to 2013.¹⁶ They showed that the functional factors associated with a negative prognosis after surgery were anterior or anterolateral location of the tumor, prolonged presentation before diagnosis, not benign pathology, Simpson grade II and III, sphincter involvement, and worse functional grade at onset. Hua et al. retrospectively analyzed 194 of 483 cases of spinal meningiomas that were treated surgically.¹⁷ The mean follow-up period was 94.34 months. A total of 9 cases (4.6%) demonstrated tumor recurrence associated with high WHO grade, male, prior recurrence, and Simpson grade III. There is much debate about the possible risk of recurrence, but Simpson grade 2 resection of spinal meningiomas may be accepted from a medium to long-term perspective.

It may be true that the choice of surgical method or surgical approach depends on neurosurgical or orthopedic concepts. Kawahara proposed the surgical technique of recapping T-saw laminocostotransversoplasty to obtain greater access to the anterior thoracic spinal canal, as well as anatomical reconstruction of the excised bone.⁵ We previously reported the technical efficacy of the posterolateral approach using the lateral oblique position for spinal meningiomas with ventral dural attachment.^{7,8} Ito et al. proposed the benefits of a posterolateral transpedicular approach for safe resection of spinal meningiomas of the ventral type at the thoracic spine.¹⁸ Removal of one pedicle and facet joint appeared to be helpful. Tola et al. reported their surgical outcomes in 20 patients with spinal meningiomas.¹⁹ The posterior unilateral approach allowed for complete resection of Simpson grade 1 or 2 in 18 patients (90%), including the ventral type of spinal meningiomas. No patients experienced either worsening of neurological status or surgery-related complications. They suggested that the posterior unilateral approach is an effective surgical approach, even in patients with the ventral type of spinal meningiomas. Onken et al. compared the surgical outcomes using the posterior unilateral approach between spinal meningiomas located anterior to the dentate ligament and those posterior to the dentate ligament.²⁰ Their study included 48 cases of ventral meningiomas, 86 lateral meningiomas, and 76 dorsal meningiomas. Ventral meningiomas that were resected using a posterior unilateral approach showed reduced duration of surgery and had complication rates and neurological outcomes comparable to those that were resected using the bilateral approach. No significant differences in complications, outcomes, and extent of resection were seen between ventral and dorsal meningiomas. There is another technical attempt to achieve complete or meticulous Simpson grade II. Saito et al. proposed the technical benefits of separating the outer and inner layers of the dura and resecting the inner layer along with the meningiomas.²¹ Although the

surgical approach to spinal meningiomas with ventral attachment is controversial, it goes without saying that treating the spinal cord with minimal pressure is fundamental.

There were several limitations in this retrospective case analysis. First, the number of subjects analyzed was not enough to reach the definite conclusion. A larger population of subjects would be desirable to better understand the clinical picture of this kind of relatively rare disease entity. Second, since this retrospective study was conducted at a single institute, the results might be affected by various institutional factors; multicenter analysis is absolutely necessary to address these limitations. Finally, the postoperative follow-up duration in this study was still not sufficient to fully understand the risk of recurrence of spinal meningiomas after complete resection. Further follow-up of longer than 10 years of this same cohort will be done.

5. Conclusions

There are still many points to be discussed regarding the long-term surgical outcomes of spinal benign meningiomas, such as the choice of surgical method or approach. This study suggested that meticulous Simpson grade 2 resection of spinal benign meningiomas of WHO grade 1 may be good enough from a medium to long-term follow-up perspective, though longer follow-up is absolutely necessary.

Conflicts of interest/disclosures

The authors declare that they have no financial or other conflicts of interest in relation to this research and its publication.

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FIGURE LEGENDS

Fig. 1. Classification of tumor localization. The location of spinal meningiomas was classified as ventral or dorsal type based on the operative video record and preoperative T1-weighted enhanced MR images. A: Ventral type, B: Dorsal type.

Fig. 2. A flowchart for selection of the surgical approach.

Fig. 3. Extent of tumor resection based on Simpson grade.

Fig. 4. Surgical outcomes based on the modified McCormick functional schema and the sensory pain scale. *: $p < 0.01$

Fig. 5. Illustrative case 1: Ventral meningioma at the craniovertebral junction.

A: Preoperative T1-weighted enhanced MR sagittal images showing the ventral attachment of the meningioma.

B: Preoperative T2-weighted MR sagittal images showing severe compression of the spinal cord.

C: Postoperative T2-weighted MR sagittal images showing satisfactory resection of the meningioma.

Fig. 6. Illustrative case 2: Ventral meningioma at the cervicothoracic junction.

A: Preoperative T1-weighted enhanced MR sagittal images showing the ventral attachment of the meningioma.

B: Preoperative T2-weighted MR sagittal images showing severe compression of the spinal cord.

C: Postoperative T2-weighted MR sagittal images showing the satisfactory resection of the meningioma.