

Spinal meningiomas: surgical management and outcome

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Advances in imaging and surgical technique have improved the treatment of spinal meningiomas; these include magnetic resonance imaging, intraoperative ultrasonography, neuromonitoring, the operative microscope, and ultrasonic cavitation aspirators. This study is a retrospective review of all patients treated at a single institution and with a pathologically confirmed diagnosis of spinal meningioma. Additionally the authors analyze data obtained in 556 patients reported in six large series in the literature, evaluating surgical techniques, results, and functional outcomes. Overall, surgical treatment of spinal meningiomas is associated with favorable outcomes. Spinal meningiomas can be completely resected, are associated with postoperative functional improvement, and the rate of recurrence is low.

KEY WORDS • spinal meningioma • spinal tumor • intradural • extramedullary

Spinal meningiomas represent 25 to 46% of tumors of the spine.⁹ Typically, they are located in the intradural extramedullary space, grow slowly, and spread laterally in the subarachnoid space until they induce symptoms. They most frequently occur in the thoracic region in middle-aged women.^{8,12,13,16,22,25} Patients typically present with pain, sensory loss, weakness, and sphincter disturbances. Advances in radiological and surgical assistive devices (MR imaging, neuromonitoring, intraoperative ultrasonography, operative microscope, and ultrasonic surgical aspirator) have resulted in earlier diagnosis and aided in obtaining a total resection. Prognosis in patients with spinal meningiomas is excellent, and even patients with a poor preoperative neurological status can respond favorably to surgery.

The purpose of this study is threefold. First, we describe a case of spinal meningioma and provide radiological and intraoperative findings, as well as a video, demonstrating the typical presentation and surgical treatment of spinal meningiomas. Second, we review a recent series of 25 patients in whom spinal meningiomas were resected. Finally, we review the literature to determine the various surgical management strategies for spinal meningiomas.

CLINICAL MATERIAL AND METHODS

We performed a retrospective chart review of all pa-

Abbreviations used in this paper: CSF = cerebrospinal fluid; MR = magnetic resonance; SSEP = somatosensory evoked potential; Tc-MEP = transcranial motor evoked potential.

tients in whom a histologically diagnosed meningioma was resected between 1992 and 2002. Of 335 patients who met these criteria, there were 25 cases (7.5%) of spinal meningiomas. We evaluated the medical records, operative reports, follow-up information, and neuroradiological findings in these 25 patients. The mean follow-up time was 23 months (range 1–64 months). Additionally, we performed a Medline search of articles published between 1982 and 2002, using “spinal meningioma” as the key word. The search turned up six series with a total of 556 patients (Table 1). We combined our series with data obtained from those in the literature and evaluated mode of presentation, tumor characteristics, surgical techniques, functional outcomes, complications, and recurrences.

CASE ILLUSTRATION

History and Physical Examination. This 77-year-old man had a 4-month history of numbness in his toes that progressed to his entire body below the nipple. He also noted progressive weakness in his lower extremities, gait instability, inability to ambulate without assistance, and urinary and fecal incontinence. On examination, 4/5 motor strength in his right lower extremity and 4+/5 motor strength in his left lower extremity were demonstrated. Extensor reflexes, clonus, and bilateral hyperreflexiveness were also found bilaterally. A sensory deficit was present below the T-3 level.

Magnetic resonance imaging revealed a large right-sided T-2 intradural extramedullary mass that was isointense to spinal cord on T₁- (Fig. 1A) and T₂-weighted sequences; homogenous enhancement was apparent after

TABLE 1

Summary of demographic data in published series of spinal meningiomas included in the current review

Authors & Year	No. of Cases	No. of Ops	Male/ Female	Mean Age (yrs)
Levy, et al., 1982	97	97	4:1	53
Solero, et al., 1989	174	184	3:1	56
Roux, et al., 1996	54	54	4:1	54
King, et al., 1998	78	78	4.1:1	62
Klekamp & Samii, 1999	117	130	3.9:1	57
Gezen, et al., 2000	36	36	3:1	49
present study, 2003	25	25	4.2:1	60

Gd administration (Fig. 1B). The spinal cord was severely compressed and displaced toward the left (Fig. 1C).

Operation. The patient was positioned prone after placement of electromyographic and SSEP monitoring devices. After T1–3 laminectomies, the dura mater was exposed and a yellow discoloration was noted. Ultrasonography confirmed tumor location at the T-2 level. An operative microscope was used. The dura was incised at the midline, exposing an extramedullary mass compressing and displacing the spinal cord to the left (Fig. 2 and Video). A plane was developed between the normal spinal cord and tumor by performing sharp microdissection. Microscissors, bipolar cauterization, and the ultrasonic surgical aspirator were used to debulk the tumor centrally to achieve decompression. Using the microscissors and microdissector, the tumor and its dural attachment at the right side were removed from the spinal cord. The dural attachment was thoroughly coagulated using bipolar cauterization. A gross-total resection was achieved. Finally, the dura was closed.

Pathological Examination. Microscopic evaluation demonstrated nests of tumor cells with abundant cyto-

Click here to view video clip: Demonstrated in the video clip is the resection of a T-2 intradural extramedullary spinal meningioma. Note that the meningioma is located at the superior aspect of the screen and the spinal cord is inferior to this tumor. First, a plane is developed between the normal spinal cord and tumor by using sharp microdissection. The tumor is then internally debulked using bipolar cauterization, microscissors, and the surgical ultrasonic aspirator. After this, the meningioma is carefully rolled away from the spinal cord toward its dural attachment. Finally, using microscissors, the tumor capsule is resected from its dural attachment and the dura is coagulated to remove additional tumor cells. At the conclusion, the dural is closed primarily.

plasm and bland oval nuclei. There were occasional psammoma bodies. The findings were consistent with spinal meningioma.

Postoperative Course. The patient remained supine for 48 hours after surgery. Postoperative MR imaging revealed no evidence of residual tumor. Prior to discharge from the hospital on postoperative Day 4, he ambulated with a cane, and lower-extremity strength and sensation had improved. He benefited from a short stay in the inpatient rehabilitation unit. Two months after surgery, the patient had regained full urinary and bowel continence, ambulated without an assistive device, and exhibited normal motor strength with only mild residual numbness in his toes.

SPINAL MENINGIOMAS: MANAGEMENT AND OUTCOME

Epidemiological Features

The annual incidence of primary intraspinal neoplasm is approximately five per million for females and three per million for males.⁹ Spinal intradural extramedullary tumors account for two thirds of all intraspinal neoplasms and include neuromas and meningiomas.¹ Overall, meningiomas account for 25 to 46% of primary spinal neo-



Fig. 1. A and B: Sagittal T₁-weighted MR images of the thoracic spine before (A) and after (B) Gd administration demonstrating an intradural extramedullary, isointense meningioma at T-2 that homogeneously enhances. C: Axial image revealing that the mass severely compresses and displaces the spinal cord (arrowhead) to the left.

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Fig. 2. Intraoperative photograph obtained using the operative microscope demonstrating the intradural extamedullary meningioma attached to the lateral dura surface and severely compressing the spinal cord.

plasms and are the second most common intradural spine tumor after neuromas.⁹ Spinal meningiomas occur less frequently than intracranial ones and account for approximately 7.5 to 12.7% of all meningiomas.²⁵

Spinal meningiomas most often affect middle-aged women. The female/male ratio is overrepresented compared with intracranial meningiomas. We found the female/male ratio in the present review to be between 3 and 4.2:1 (mean age range 49–62 years [Table 1]). It has been suggested that spinal meningiomas occur more frequently in women because of a possible dependence on sex hormones.^{20,25} Although the effect of sex hormones on meningiomas is controversial, the authors of hormone studies have shown the existence of various other receptor types (steroid, peptidergic, growth factor, and aminergic) that may contribute to tumor formation.²⁰

Genetic Alterations

In genetic studies investigators have shown complete or partial loss of chromosome 22 in greater than 50% of patients with spinal meningiomas.^{2,11} Arslantas, et al.,² reported abnormalities of cancer-related genes located on 1p, 9p, 10q, and 17q in spinal meningiomas and concluded that they might be involved in the cause of spinal meningiomas. Interestingly, Ketter, et al.,¹¹ stated that all spinal meningiomas in their series (23 of 198) had a normal chromosomal set or a monosomy of 22. This genotype was not associated with disease recurrence, in contrast to intracranial meningiomas, which had a higher rate of tumors with multiple chromosomal aberrations, correlating with higher rates of recurrences.

Tumor Locations

In this review, the most frequent location of spinal meningiomas was the thoracic region (67–84%) (Table 2). They occurred far less frequently in the cervical spine (14–27%) and only rarely in the lumbar spine (2–14%). Cohen-Gadol, et al.,³ found that in patients younger than 50 years of age there tended to be a higher frequency (39%) of spinal meningiomas located in the cervical spine, and the majority were located in the high cervical

TABLE 2
Location and relation of tumor to the spinal cord

Authors & Year	Spinal Cord Location (%)			Relation to Spine (%)		
	Cervical	Thoracic	Lumbar	Lat	Posterior	Anterior
Levy, et al., 1982	17	75	7	13	51†	36†
Solero, et al., 1989	15	83	2	68	18	15
Roux, et al., 1996	18	80	2	22	33†	39†
King, et al., 1998	14	84	2	71	10	19
Klekamp & Samii, 1999	27	67	6	45	28	27
Gezen, et al., 2000	14	72*	14	50	31	19
present study, 2003	16	76	8	48	36	16

* Including cervicothoracic and thoracolumbar meningiomas.

† Including posterolateral and anterolateral tumors.

region. Levy, et al.,¹⁶ reported that tumor location varied according to sex, with significantly more thoracic spine meningiomas appearing in female patients. In addition, they found that cervical meningiomas were more likely to be located ventral to the cord.

We found that spinal meningiomas were located lateral to the spinal cord or had a component that extended laterally (Table 2). A posterior location was more frequent than an anterior one.

Spinal meningiomas were typically intradural and extramedullary (83–94%). In our series, all 25 patients harbored intradural extramedullary meningiomas, whereas in the reviewed series 5 to 14% of tumors had an extradural component.^{8,12,13,16,22,25} There were several cases of entirely extradural meningiomas (3–9%).^{12,22,25}

Diagnostic Evaluation and Imaging

There was typically a delay between the onset of symptoms and diagnosis. The mean duration of symptoms prior to presentation was 1 to 2 years.^{12,13,16,22} In the present series and in the literature, some patients noted pain symptoms beginning 15 to 20 years prior to diagnosis of spinal meningioma.¹⁶ Patients often presented with pain, sensorimotor deficits, and sphincter disturbances (Table 3). Typically, back or radicular pain preceded the weakness and sensory changes; the sphincter dysfunction was always a late finding. Additionally, signs of myelopathy were present in most patients. In our series, weakness was present

TABLE 3
Symptoms and signs of spinal meningiomas*

Authors & Year	Presenting Symptom (%)			
	Pain	Weakness	Sensory	Sphincter Dysfunction
Levy, et al., 1982	77	66	74	40
Solero, et al., 1989	53	92	61	50
Roux, et al., 1996	72	80	67	37
King, et al., 1998	23†	NA	28†	61
Klekamp & Samii, 1999	50†	16†	6†	6†
Gezen, et al., 2000	83	83	50	36
present study, 2003	68	64	84	48

* NA = not applicable.

† Values reflect first symptom.

in 64%, and 32% of the patients were nonambulatory at the time of presentation.

Prior to the advent of MR imaging, spinal meningiomas were often confused with multiple sclerosis, syringomyelia, pernicious anemia, and herniated disc.^{8,16} Levy, et al.,¹⁶ reported that the rate of misdiagnosis in their pre-MR imaging series was 33% and that errors in diagnosis delayed treatment, sometimes leading to inappropriate surgery. Seven of their patients underwent inappropriate surgeries, including lumbar disc exploration and knee surgery. In our series, a misdiagnosis of multiple sclerosis was made in one case and arthritis in another.

Magnetic resonance imaging is the best imaging technique for diagnosing spinal meningiomas. It clearly delineates the level of the tumor and its relation to the cord, which is useful in planning surgery. In the past, plain radiography was used to detect calcified meningiomas, but calcifications are only visible on 2 to 5% of plain x-ray films.²⁵ Prior to the advent of MR imaging, myelography was the radiological modality of choice.^{16,25} Klekamp and Samii¹³ reported that MR imaging led to earlier diagnosis of spinal meningiomas by 6 months and, on average, patients suffered less severe neurological deficits at the time of surgery. Typically, spinal meningiomas were iso-intense to the normal spinal cord on T₁- and T₂-weighted images, and they displayed intense enhancement after Gd injection.⁸

Intraoperative ultrasonography has been useful in the identification and localization of meningiomas,¹⁷ providing useful information about its size and the degree to which it displaces the spinal cord. Typical ultrasonographic features include echogenicity, irregular surfaces, and tight adherence to the dura.¹⁷

Surgical Approach

In the reviewed series, all patients underwent classic posterior laminectomies. In cases in which meningiomas were located anteriorly the laminectomy was extended laterally toward the articular process to provide sufficient exposure and cause minimal displacement of the spinal cord. Excluding those in the earlier series, patients underwent surgeries involving the operating microscope (Table 4). Ultrasonography provided detailed localization of meningiomas, thereby avoiding unnecessarily large dural openings. The goal of surgery was to minimize displacement of the spinal cord by undertaking an appropriately

wide exposure, making the tumor and its dural attachment accessible. Sometimes this was accomplished by cutting one or more dentate ligaments. After dural opening, a plane was developed between the arachnoid and the tumor. The tumor was then internally debulked using suction, an ultrasonic surgical aspirator, microscissors, or laser. In the more recent series, increased use of the ultrasonic surgical aspirator and laser was apparent. After debulking, in the majority of cases the tumor was rolled away from the spinal cord and toward its dural attachment. The tumor was then removed from its dural attachment. Dura with remaining tumor was either coagulated using bipolar cauterization or resected (Table 5). In the majority of cases, including our series, the dural attachment was cauterized rather than resected. The dural attachment was always cauterized in cases involving an anterior dural attachment. Additionally, in most cases the dura was closed primarily, compared with suturing in a graft, which was performed far less frequently (Table 5). Another option was separation of the dura into an outer and inner layer and to resect the tumor with the inner layer, leaving the outer layer available for closure.²³

Neuromonitoring Techniques

Neuromonitoring may reduce the likelihood of postoperative neurological deficits as a result of resecting spinal cord meningiomas. This modality provides data on the extent of tissue manipulation, does not compromise function, and may potentially lead to preservation of function; the benefits justify its use and the risks associated with extended operating time. Two commonly used modalities described in the reviewed series were muscle Tc-MEP and SSEP monitoring. Transcranial-MEPs were obtained by placing stimulating electrodes over the patient's motor cortical regions and recording electromyographic activity either epidurally or at the extremities.¹⁴ This method was useful for tumors involving the anterior and/or anterolateral spinal canal and compressing of the corticospinal tracts. The SSEP recordings were useful in tumors located in the posterior or posterolateral aspect of the canal and compressing the dorsal columns.

The advantage of muscle Tc-MEP monitoring is that it allows assessment of motor function from the cortex to beyond the neuromuscular junction. The Tc-MEPs were

TABLE 4
Surgical equipment and percent of complete resections*

Authors & Year	Op Device (%)			Total Resection (%)
	Microscope	US Aspirator	Laser	
Levy, et al., 1982	NA	NA	NA	82
Solero, et al., 1989	17	NA	NA	97
Roux, et al., 1996	63	18	22	93
King, et al., 1998	NA	NA	NA	99
Klekamp & Samii, 1999	NA	NA	NA	89
Gezen, et al., 2000	100	NA	NA	97
present study, 2003	100	63	4	92

* US = ultrasonic surgical.

TABLE 5
Approaches to dural attachment and dural closure

Authors & Year	Resection (%)		Dural Repair (%)	
	Dural	Coagulation	Primary Closure	Graft
Levy, et al., 1982	57	15	15	8*
Solero, et al., 1989	14	86	86	14
Roux, et al., 1996	15	85	89	11
King, et al., 1998	26	74	NA	NA
Klekamp & Samii, 1999	NA	NA	NA	NA
Gezen, et al., 2000	NA	NA	NA	NA
present study, 2003	16†	88	88	12

* Performed in 77% of patients with the dura left open.

† One patient underwent a split-thickness removal of dura followed by coagulation.

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recorded directly in the muscles being assessed. In addition, muscle Tc-MEPs can be recorded from all four individual extremities, allowing evaluation of the extremity most affected by surgical manipulation. One limitation of this modality in the reviewed series was that the potentials were often blocked after induction of general anesthesia.³⁰ The use of a multiple impulse technique (short train of stimuli) helped resolve this problem. The Tc-MEPs induced by multiple stimuli were much less sensitive to the effects of general anesthesia than those evoked by a single stimulus.^{10,21,27}

Somatosensory evoked potentials were traditionally used by various investigators to evaluate cerebral function in procedures involving intracranial aneurysms and tumors.^{6,7,19,24,28} Recently, its utility has been extended to the resection of intramedullary spinal cord tumors and extra-axial spinal cord tumors. This monitoring modality consists of stimulating the median and tibial nerves bilaterally and recording orthodromic SSEPs from both cortical and spinal epidural electrodes throughout the procedure.¹⁴ When spinal meningiomas were resected, this monitoring was used to detect changes in the SSEP responses as a real-time feedback for the surgeon. Manipulation of the spinal cord can lead to changes in SSEP signals and prompt the surgeon to decrease manipulation or to change techniques such as retraction. This feedback is relevant in the thoracic spine where space was limited. Somatosensory evoked potentials can be recorded throughout surgery without risk of patient movement and correlated with postoperative sensory findings, particularly proprioception (joint position sense).¹⁴ Unfortunately, SSEPs are fragile monitored circuits and lack correlation with postoperative motor function.²⁹ During resection of spinal meningiomas, motor and sensory pathways could be affected separately.²⁶ Several groups reported postoperative motor deficits despite recording normal intraoperative SSEPs during tumor resection.^{15,31}

Histopathological Characteristics

The most common histological features of spinal meningioma include meningotheliomatous, fibroblastic, transitional, and psammomatous.^{8,12,13,16,22,25} Meningotheliomatous and psammomatous types were the predominant histopathological lesions.^{8,12,13,16,22,25} The histological type did not seem to influence prognosis, except if malignancy was evident.^{12,22,25}

Surgical Results

Complete resection was achieved in 82 to 99% of cases (Table 4).^{8,12,13,16,22,25} In our series, total resection was achieved in 23 (92%) of 25 patients. Of the two subtotal resections, one was performed in a patient with a large, calcified anterior C2–5 spinal meningioma. The surgery was complicated by extensive calcifications and by the tumor's adherence to the dura and its anterior extension. The other subtotal resection was performed in a patient with a large meningioma extending from T-12 to L-2 that diffusely infiltrated the conus medullaris.

In general, anterior, en plaque, recurrent tumors with arachnoid scarring and calcified meningiomas were implicated as potential challenges for total resection.^{13,16,22,25} The benefits of complete resection need to be weighed

against the potential for spinal cord damage. In the reviewed series, the main technical challenge involving anterior meningiomas was gaining access to the tumor and its attachment. En plaque meningiomas were a surgical challenge because they did not respect tissue planes, had a more extensive tumor matrix, infiltrated surrounding structures, and occasionally showed ossifications.^{5,13} Klekamp and Samii¹³ reported that only 53% of en plaque tumors were completely resected compared with 97% of encapsulated meningiomas. In surgery for recurrent lesions, arachnoid scarring complicating the procedure was found in 90% of cases compared with 11% in primary meningiomas.¹³ Surgery for recurrent meningiomas was difficult because adhesions caused cord tethering; difficulty in distinguishing between scar, meningioma, and spinal cord; absence of an arachnoidal interface; and in some cases pia infiltration.¹³ Klekamp and Samii reported that only 45% of recurrent tumors were completely resected compared with 95% of the first operations; additionally only tumors in cases involving arachnoid scarring were completely resected in only 70%, whereas in the absence of scarring complete excision was possible in 94%. They recommended sharp dissection of arachnoid scars, meticulous hemostasis, and decompression of the subarachnoid space by placing a dural graft, providing protection against significant postoperative tethering and CSF obstruction. Calcified meningiomas were also difficult to resect because of adhesions to the spinal cord.^{5,16,22} Levy, et al.,¹⁶ reported poor functional outcomes in three of four patients harboring calcified tumors; the patients became paraplegic as a result of the additional manipulations required to dissect the tumor.

Some authors of the reviewed series believed that epidural meningiomas¹⁶ and meningiomas located close to a radicomedullary artery²² may represent surgical challenges. It was thought that spinal meningiomas with epidural extension exhibited a more rapid clinical course and were more invasive.¹⁶ Others argued that these lesions did not represent a unique subgroup and had an indolent course.^{22,25} Roux, et al.,²² asserted that total resection of spinal meningiomas in proximity to a radicomedullary artery feeding the anterior spinal artery was dangerous, and they advocated the use of spinal angiography in all patients. One patient in their series suffered permanent postoperative paraplegia due to anterior spinal artery ischemia.

Functional Outcome

Overall, functional improvement occurred in 53 to 95% of cases and neurological deterioration was demonstrated in 0 to 10% (Table 6).^{8,12,13,16,22,25} The mean follow-up intervals ranged from 20 to 180 months. In our review we found that even patients with severe preoperative neurological deficits may experience a full neurological recovery after careful surgical interventions and appropriate rehabilitation.^{13,16} For example, King, et al.,¹² found that three of four patients with preoperative paraplegia were independently mobile and asymptomatic in the postoperative period. Overall the majority of patients, (75–97%) were ambulatory postoperatively, whereas before surgery 33 to 74% of patients were able to walk (Table 6). King, et al.,¹² found that 35 (95%) of 37 patients with preopera-

TABLE 6
Functional outcomes after surgery for spinal meningiomas

Authors & Year	Outcome (%)			Ambulatory (%)	
	Im- proved	Stable	Dete- riorated	Preop	Postop
Levy, et al., 1982	83	17	0	70	76
Solero, et al., 1989	53	37	10	70	92
Roux, et al., 1996	85	13	2	67	94
King, et al., 1998	95	1	4	74	97
Klekamp & Samii, 1999	NA	NA	NA	74	94
Gezen, et al., 2000	83	14	3	33	75
present study, 2003	92	0	8	68	96

tive bladder dysfunction exhibited normal function after surgery. Some patients suffered transient neurological worsening postoperatively, typically secondary to vasogenic edema or as a result of dissection, but function generally recovered after 6 months.^{13,22,25}

Surgical Complications

Mortality and morbidity rates were low. In published studies, the mortality rate ranged from 0 to 3% (Table 7), and the cause of death was unrelated to the primary disease in all cases reviewed. Causes of death in the reviewed series included pulmonary embolism, aspiration pneumonia, stroke, and myocardial infarction.^{12,13,16,25} The incidence of CSF leakage was low (0–4%).

Tumor Recurrence

Recurrence of spinal meningiomas was rare, and in most series the rate ranged from 1.3 to 6.4% (Table 7).^{8,12,16,22,25} Ketter, et al.,¹¹ reported that spinal meningiomas did not have the genetic abnormalities found in recurrent intracranial meningiomas, suggesting that they had a more indolent nature. The slow growth of spinal meningiomas and their presentation in patients at a late age contributed to the low recurrence rates.¹² In the reviewed series, recurrences occurred at 1 to 17 years (Table 7). In our series, one patient (4%) suffered a recurrence 2 years after subtotal resection of a large, infiltrative conus medullaris meningioma.

Significantly higher recurrence rates were found in

cases involving en plaque or infiltrating meningiomas, tumors with arachnoid scarring, and in partially resected lesions.¹³ Klekamp and Samii¹³ stated that in patients in whom complete resection was performed, 29.5% experienced a recurrence within 5 years of surgery, whereas in all patients with partially removed tumors the lesion had recurred by that time. In general, the course of a spinal meningioma appeared to be more benign than its intracranial counterpart. Mirimanoff, et al.,¹⁸ reported a recurrence rate of 13% at 10 years, which was far lower than those reported for convexity meningiomas (3 and 25% after 5 and 10 years, respectively) and parasagittal meningiomas (18 and 24% after 5 and 10 years). Unlike intracranial meningiomas, there was no correlation between recurrence and the resection of dural attachment.^{8,12,13,25} Comparing radical dural resection and dural coagulation, Solero, et al.,²⁵ reported recurrence rates of 8 and 5.6%, Levy, et al.,¹⁶ reported 4 and 0%, and Klekamp and Samii reported 31.3 and 26.1%, respectively.

Cohen-Gadol, et al.,³ found that rates of recurrence and reoperation in patients younger than 50 years of age were higher than those in older patients because of a higher frequency of spinal meningiomas with cervical spine locations, extradural tumor extension, and en plaque growth, all of which made total resection more difficult. Deen, et al.,⁴ also reported a higher rate of recurrence (20%) in patients younger than 21 years of age.

Adjunctive Radiotherapy

Although the optimal treatment for primary spinal meningioma was total microsurgical resection, some authors advocated adjunctive radiotherapy in cases of recurrent tumors.^{8,22} Its role as adjuvant therapy after subtotal resection was controversial because of the tumor's typically indolent nature.^{8,22} It has been indicated that radiotherapy should be considered after subtotal primary excision in cases of recurrent meningiomas, or as an alternative to surgery when the operative risk is too high because of comorbidities or tumor location.^{8,18,22} Surgery for recurrent spinal meningiomas was performed before radiotherapy if the tumor was accessible.^{8,18,22} Gezen, et al.,⁸ reported no recurrence in the two patients who underwent radiotherapy for recurrent spinal meningioma. Roux, et al.,²² also performed radiosurgery in two patients with recurrences, and the patients were stable at a follow-up examination

TABLE 7
Surgical morbidity and mortality and the rate/timing of recurrence*

Authors & Year	Mortality (%)	Morbidity (%)			Recurrence	
		CSF Leak	Wound Infection	Mean FU (mos)	Incidence	Timing (yrs)
Levy, et al., 1982	1	3	1	84	3.1	8–16
Solero, et al., 1989	1	1	1	180	6.4	1–17
Roux, et al., 1996	0	0	1	28	3.7	2
King, et al., 1998	1	4	0	132†	1.3	14
Klekamp & Samii, 1999	2	4	1	20	14.7	NA
Gezen, et al., 2000	3	3	6	108	5.6	5–8
present study, 2003	0	0	0	23	4.0	2

* FU = follow up.

† Value represents the median number of follow-up months.

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after 5 years. In our series, the one patient in whom recurrence was demonstrated underwent radiotherapy, leading to decreased tumor size and stabilization of neurological function. Overall, one can anticipate that new radiosurgery techniques will be useful in the treatment of recurrent spinal meningiomas.

CONCLUSIONS

Surgery is the preferred treatment in cases of spinal meningiomas because of its associated excellent functional improvement and low recurrence rates. Radiosurgery should be considered for the exceptional case involving recurrent and symptomatic spinal meningiomas.

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