Planning of Surgical Management of Spinal Schwannomas

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ABSTRACT

Background: Intradural tumors of the spine are usually benign and carry a good prognosis, if they are diagnosed and removed early. Schwannomas make up almost one-third of primary spinal neoplasms. Spinal schwannomas are typically intradural-extramedullary neoplasms thought to be arisen from Schwann cells or their progenitors, which occur proportionally throughout the spinal canal. Objective: Evaluation of twelve consecutive cases of surgically resected spinal schwannomas. Patients and Methods: The first author has operated on twelve consecutive cases of spinal schwannomas at two different centers in KSA over seven years (2007-2014), seven cases at KASH (Taif) and five cases at KSMH (Tabouk). Full MRI craniospinal survey. CT-3D (reformatted image) study for surgical area of concern with accurate preoperative panning for extent of bony resection to avoid iatrogenic spinal instability. Stick on the preoperative plan as much as possible. Immediate postoperative imaging with MRI and CT-3D to evaluate the mass resection, the extent of bony removal, evaluation of the preoperative planning and spinal stability. The final diagnosis was established by immunohistochemical study. Results: We treated twelve spinal schwannomas seven females (58%) and five males (42%). The age interval was 20-59 years. The mean age was 43.3. The tumor was located in the lumbar region in six patients (50%), the thoracic region in three patients (25%), and the cervical region in another three patients (25%). The most frequent complaints included back pain, neck pain, radiculopathy, myelopathy, motor weakness, and voiding difficulty. The onset of the symptoms ranged from 2 weeks to 16 months. The motor functions were evaluated and documented. Follow-ups from 18 to 44 months showed that the symptoms and signs had significantly improved, and no complication of surgery or spinal abnormality occurred in any of the patients that necessitated further spinal intervention or fusion except one case with irrelevant indication. None of our patients presented with clinical deterioration and none of them died. However, one case (8.3%) showed radiological recurrence after thirty eight months. The location of all schwannomas were intradural extramedullary. Conclusion: the spine surgeon should always keep in mind that in the differential diagnosis of neck or low back pain, intradural spine tumors are included and that despite complete resection, these benign extramedullary tumors present a continued risk of recurrence. We also suggest that a wide laminectomy may cause iatrogenic instability and necessitate spinal fusion. Therefore, adequate preoperative planning for extent of bony resection for each case may obviate the need for spinal fusion.

INTRODUCTION

Intradural tumors of the spine are usually benign and carry a good prognosis, if they are diagnosed and removed early. Early symptoms of these tumors are non-specific and their progression can be subtle. The duration of symptoms usually ranges from 3 to 4 years prior to the diagnosis. Low back pain may be the only apparent symptom during this time. Schwannomas or neurilemmomas comprise neurogenic benign tumors that derive from the nerve sheath. Microscopic evaluation has proven their origin from myelinated Schwann cells, contrary to neurinomas that are nerve-fibre tumors.

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Schwannomas, that is, tumors derived from neoplastic Schwann cells, and neurofibromas represent the most common intradural extramedullary lesions, accounting for approximately 30% of all nerve sheath tumors in adults.

According to western studies, the incidence of spinal schwannomas varies between 0.3-0.4 cases/100,000 persons per year.

Spinal schwannoma was first reported in 1954. The location of the tumor can be anywhere along the neuroaxis. Schwannomas usually occur intradurally, extradurally and occasionally intra and extradurally. As Schwann cells are not typically found in the parenchyma of the central nervous system, these tumors are rarely observed within the spinal cord.

The lumbar site is more frequent (44%) than the cervical site (31%) and the thoracic site (25%).
Schwannomas are benign tumours, but can be locally aggressive and cause catastrophic neurological compromise. Schwannomas seem to appear between the third and the sixth decades. Radiologically schwannomas commonly appear as ‘dumbbells’ that traverse across the dural lining. These tumors are usually lobulated, encapsulated, and well demarcated. That typically show homogeneous or heterogeneous enhancement and that are variably hyperintense on T2 weighted magnetic resonance (MR) images.

Histologically, schwannomas are typically well-limited, encapsulated, and lobulated tumors. There are two types of tissues: Antoni type A tissue consisting of compact cellular area of spindle-shaped cells arranged in bundles or fascicles and Antoni type B tissue which is less cellular with hazardly arranged spindle-shaped cells.

In immunohistochemical study, protein S100 is positive. The tumors may undergo cystic degeneration, hemorrhage, or xanthomatous changes. Sparse mitotic hyperchromatic nuclei and degenerative changes, such as cyst formation, calcification, with only occasional sites of hemorrhage are the major histopathological characteristics of the ancient forms of schwannomas.

Because of the propensity of multiple benign schwannomas for neurofibromatosis type II patients to develop schwannomas, genetic testing for the neurofibromatosis mutation as well as merlin, a tumor suppressor gene localized on chromosome 22q12, should be performed in patients diagnosed with spinal cord schwannomas.

Clinical and radiological features cannot predict the malignancy or the benignity of the tumor. Malignant lesions are more commonly associated with neurofibromatosis type I and should be considered in solitary tumor cases if other cutaneous manifestations are present.

Schwannomas arise as an eccentric growth from the cells of the peripheral or cranial nerves (excluding the optic and olfactory nerves) and spinal roots sheath. They have also been described to occur at various other sites such as skin, oral cavity, and lacrymal glands. Schwannomas are usually solitary but can also be found at multiple sites along the same nerve sheath.

Intraoperative neurophysiological monitoring has been utilized in attempts to minimize neurological morbidity from operative manipulations. The success and feasibility of the use of spinal motor evoked potential (MEP) have been studied in a survey recommending the use of somatosensory evoked potential (SSEP) and spinal motor evoked potential (MEP) together in operations where there was risk of spinal cord injury.

**Objective:** Evaluation of twelve consecutive cases of surgically resected spinal schwannomas.

**PATIENTS AND METHODS**

The first author has operated on twelve cases of spinal schwannomas at two different centers in KSA over seven years (2007-2014), seven cases at King Abdl-Aziz Specialized Hospital (Taif) and five cases at King Salman Military Hospital (Tabouk). Full MRI craniospinal survey. CT-3D (reformatted image) study for surgical area of concern with accurate preoperative planning for extent of bony resection to avoid iatrogenic spinal instability. Stick on the preoperative plan as much as possible. Immediate postoperative imaging with MRI and CT-3D to evaluate the mass resection, the extent of bony resection, the preoperative planning and spinal stability. The final diagnosis was established by immunohistochemical study. Neither neurophysiological monitoring nor genetic testing was done for any of those patients. Sridhar classification was used for the location of the tumors (Table 1).

We documented the data and surgical treatment of twelve consecutive patients who were diagnosed spinal schwannoma, operated, and followed up by the first author between 2007 and 2014. The age, sex, onset complaints, radiological diagnosis, neurological examination, surgical techniques, immunohistochemical study and outcome of the patients were documented and depicted in (Table 2). We performed different spinal approaches on our patients according to the tumor location and extension (Table 2).

The range of bony resection was from unilateral interlaminar to full bilateral laminectomy (with facet preservation) according to the location, size and extensions of the mass. Opening the dura along the longitudinal axis of the mass and fashioned according to its extension. Schwannomas were microsurgically dissected from the root and totally removed with nerve preservation and the dura was primarily water tight closed.

For the cervical region, we prefer full bilateral laminectomy (with facet preservation) just enough to expose the upper and the lower poles of the mass to allow adequate CSF leak above and below the mass and release the relevant denticulate ligaments to free the cord at the surgical side prior to starting the mass dissection from the root and the cord.

For thoracic schwanna with extraspinal extension, the extradural part was removed by partial excision of the relevant rib, while the facet joint was preserved and the dura defect formed was closed by duraplasty and thin film of biological glue.

For the lumbar extraspinal location (Sridhar classification III), the tumor was located at the foramen and just lateral to it. We adopted the microscopic interlaminar approach. After insertion the interlaminar retractor, undermining the lower border of the upper lamina, shaving and thinning out the ligamentum flavum in-between. Under microscopic guidance, the...
most thickness of the ligamentum flavum was incised from lateral to medial then from medial to lateral and carefully open the junction in-between with blunt instrument at the area of the root exit; this dural reflection is the most common point of dural injury during ligamentum flavum opening. The dura was opened along the longitudinal axis of the mass. Then, the mass was microsurgically dissected from the root and totally removed with nerve preservation. Small artificial dural patch was placed over the durotomy. Radiological follow up MRI with contrast after three months as baseline, 6-month interval for two years then annually.

Table 1: Sridhar classification of benign nerve sheath tumors

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td>Intraspinal tumor &lt; 2 vertebral segments in length; a: intradural; b: extradural</td>
</tr>
<tr>
<td>Type II</td>
<td>Intraspinal tumor &gt; 2 vertebral segments in length (giant tumor)</td>
</tr>
<tr>
<td>Type III</td>
<td>Intraspinal tumor with extension into nerve root foramen</td>
</tr>
<tr>
<td>Type IV</td>
<td>Intraspinal tumor with extraspinal extension (dumbbell tumors); a: extraspinal component &lt; 2.5 cm; b: extraspinal component &gt; 2.5 cm (giant tumor)</td>
</tr>
<tr>
<td>Type V</td>
<td>Tumor with erosion into vertebral bodies (giant invasive tumor), lateral and posterior extensions into myofascial planes</td>
</tr>
</tbody>
</table>

RESULTS

We treated twelve spinal schwannomas seven females (58%) and five males (42%). The age interval was 20-59 years. The mean age was 43.3. The tumor was located in the lumbar region in 6 patients (50%), the thoracic region in 3 patients (25%), and the cervical region in 3 patients (25%). The most frequent complaints included back pain, neck pain, radiculopathy, myelopathy, motor weakness, and voiding difficulty. The onset of the symptoms was from 2 weeks to 16 months. All cases were classified between Sridhar I and III. The motor functions were evaluated and documented. The symptoms and signs of all patients had significantly improved, and no complication of surgery or spinal abnormality occurred in any of them that necessitated further spinal intervention or fusion except one case associated with pre-existing spinal canal stenosis with medially directed facets. Two facets were sacrificed and spinal fusion carried out. None of our patients presented with clinical deterioration and none of them died. Radiological recurrence after 38 months of surgery in one patient (8.3%). All patients were followed up from 18 to 44 months with a median 33.8 months (Table 2). Three different illustrative cases were discussed in details (Fig. 1,2,3).

Table 2: Evaluation of twelve patients with spinal schwannomas

<table>
<thead>
<tr>
<th>Age (year) / sex</th>
<th>Complaints and duration</th>
<th>Neurologic examination</th>
<th>Location level</th>
<th>Size</th>
<th>Sridhar classification</th>
<th>Surgical approach</th>
<th>Follow-up (Mo.)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>59/M</td>
<td>LBP with Bil. LL parathesia-10 Mo</td>
<td>Bil. radiculopathy- No deficit</td>
<td>L3-4</td>
<td>18x20 x 11 mm</td>
<td>Type I</td>
<td>L3-4 Bilateral full laminectomy</td>
<td>28</td>
<td>Stenosis(fusion)</td>
</tr>
<tr>
<td>54/F</td>
<td>Non-specific LBP-14 Mo</td>
<td>Paraparesis retention</td>
<td>L1-2</td>
<td>12x14x10mm</td>
<td>Type III</td>
<td>L1-2 full bilateral laminectomy</td>
<td>34</td>
<td>Extend foramen</td>
</tr>
<tr>
<td>48/M</td>
<td>Non-specific neck pain-4 Wk</td>
<td>Quadraparesis</td>
<td>C4-5</td>
<td>22x16 x17 mm</td>
<td>Type I</td>
<td>C4-5 bilateral full laminectomy</td>
<td>28</td>
<td>Schwann S-100(+)</td>
</tr>
<tr>
<td>35/F</td>
<td>Right leg pain-16 Mo</td>
<td>Rt. radiculopathy- No deficit</td>
<td>L4-5</td>
<td>12x12x11 mm</td>
<td>Type III</td>
<td>Right interlaminar</td>
<td>18</td>
<td>Extend foramen</td>
</tr>
<tr>
<td>48/F</td>
<td>Non- specific LBP -5 Mo</td>
<td>Rt. radiculopathy- No deficit</td>
<td>L2-3</td>
<td>15x22x12mm</td>
<td>Type I</td>
<td>L2-3 Bilateral full laminectomy</td>
<td>44</td>
<td>R-38M</td>
</tr>
<tr>
<td>38/M</td>
<td>Rt. lower abdominal pain-3 Wk</td>
<td>Urinary retention- Full bladder - Hypoesthesia</td>
<td>D12-L1</td>
<td>24 X 15 X 13 mm</td>
<td>Type I</td>
<td>D12-L1 full bilateral laminectomy</td>
<td>36</td>
<td>Cystic septae</td>
</tr>
<tr>
<td>46/M</td>
<td>Sudden paraparesis</td>
<td>urinary retention- paraparetic</td>
<td>D7-8</td>
<td>8x 11x13 mm</td>
<td>Type I</td>
<td>D7-8 unilateral laminectomy with rib resection</td>
<td>40</td>
<td>Schwann S-100(+)</td>
</tr>
<tr>
<td>20/F</td>
<td>Lt. Brachalgia-12 Mo</td>
<td>No neurological deficit</td>
<td>C4-5-6</td>
<td>32 x 15 x 10 mm</td>
<td>Type II</td>
<td>C4-5-6 bilateral full laminectomy</td>
<td>34</td>
<td>Schwann S-100(+)</td>
</tr>
<tr>
<td>34/F</td>
<td>Paraparesis- 2 Wk</td>
<td>Hypoesthesia- retention with overflow</td>
<td>D10-11</td>
<td>15x13x13 mm</td>
<td>Type II</td>
<td>D10-11 bilateral full laminectomy</td>
<td>43</td>
<td>Schwann S-100(+)</td>
</tr>
<tr>
<td>42/F</td>
<td>Lt. leg pain-6Mo</td>
<td>Lt. Radiculopathy with weak dorsiflexion</td>
<td>L5-1</td>
<td>9x8 x13 mm</td>
<td>Type III</td>
<td>Left interlaminar</td>
<td>22</td>
<td>Extend foramen</td>
</tr>
<tr>
<td>41/M</td>
<td>Non-specific Neck pain -3 Mo</td>
<td>Quadraparesis</td>
<td>C6-7</td>
<td>30x12x11 mm</td>
<td>Type II</td>
<td>C6-7 Full bilateral laminectomy</td>
<td>42</td>
<td>Schwann S-100(+)</td>
</tr>
<tr>
<td>55/F</td>
<td>Non-specific LBP-9 Mo</td>
<td>No radiculopathy- No deficit</td>
<td>L2-3</td>
<td>14x8x13 mm</td>
<td>Type I</td>
<td>L2 unilateral laminectomy</td>
<td>37</td>
<td>Schwann S-100(+)</td>
</tr>
</tbody>
</table>
Fig. 1 a-f: A 48-year old nurse presented with dull aching back pain and progressive motor deterioration. MRI showed intradural extramedullary mass at L2-L3 level. b: One of the cauda nerve roots on the right side was adherent to the tumor that was resected. c: Follow up MRI and d: CT were done, e: before discharge home. Contrast-MRI showed 3 mm of enhancement at site of surgery and the patient was symptom-free. f: Six months later, there was minimal increase in the enhanced nodule to 5 mm and the patient still pain free.
Fig. 2 a-f: a: A 38-year-old man who had a 3 week history of right lower abdominal pain with free abdominal ultrasound. The patient presented to the ER with urinary retention and bilateral paraparesis. MRI revealed D12-L1 mass with multiple areas of cystic degeneration and internal enhanced septations. b: Once the dura was incised, a cylindrical yellowish mass was found and completely dissected out of the nerve. c: The histological examination showed a fragmented tumor composed of Antoni A and Antoni B areas and d: there were scattered Verocay bodies. e: Immunohistochemistry was positive for S100 and f: GFAP.
Fig. 3 a-h: a&b: A 20-year-old lady presented with severe left brachalgia without any neurological deficit. MRI showed big mass from C4 to C6 with significant cord compression. c: CT-3D reformatted cervical spine was carried out. d: The mass was released from the ventral aspect of the cord prior to sliding it out of the neural canal then, e: dissected from left fifth cervical root. f&g: Follow up with base line contrast-MRI and h: CT were done proved complete resection of the mass, spine stability and the cord started to be normally positioned inside the neural canal.

DISCUSSION

Schwannomas are benign tumors that grow slowly and have low invasion and metastasis potential. Spinal schwannoma constitutes approximately 25% of the intradural spinal tumors. Schwannomas are frequently located in the extramedullary region, and may present as dumbbell shaped in 10-15% of cases. They may also be located at the intramedullary region. Ten percent of the tumors were in the extradural location, and 1% in the intradural intramedullary regional location.

The early diagnosis and appropriate surgical intervention resulted in good clinical outcome. Most
of Schwannomas are benign and present high histological cellularity, and are shaped like solid masses forming up of Antoni A and Antoni B. Multiple forms are generally seen in the case of neurofibromatosis. These tumors grow slowly, but malignant transformation can occur, and have been seen in the 4th and 5th decades. In our series, the age of our patients was between the 2nd and 5th decades. Although Conti and his colleagues reported that it was more frequently seen in males; McCormick and his colleagues reported that this rate was equal in both sexes. There is no significant prevalence difference between males and females. In our series, the higher incidence was seen in the males; McCormick and his colleagues reported that this rate was equal in both sexes. There is no significant prevalence difference between males and females. In our series, the female showed slight predominance (58%).

The major incidence of schwannoma is in the cervical and lumbar regions. In the report of Joen and his coworkers, the higher incidence was seen in the lumbo-sacral spine (62.5%) with a spike between L3 and L4 spines (32.5%). In our series, the most frequent location was the lumbar region (50%), the thoracic (25%) and the cervical (25%). However, McCormick and his colleagues reported another location order (the thoracic, cervical, and lumbar regions) for all intradural extramedullary tumors.

In the literature, 70 to 80% of spinal schwannomas are reported to be intradural in location, and those extending through the dural aperture as a dumbbell mass with both intradural and extradural components account for another 15%. Intradural schwannomas are extremely rare. In our series, all were in intradural extramedullary location. We believe that the location variability needs large case series.

Clinically, the first symptoms included non-specific low back, neck pain and radicular pain. It was reported that the pain increases at night and in the late period of the tumor, spinal cord findings occur as well. Other signs of spinal schwannoma included motor weakness, sphincter problems, and sensorial disorders. The range complaint period may be 2 weeks to 1 year and more. We can speculate that early diagnosis was established in most of our patients. However, the 25% presented with neurological deficit after a period of nonspecific symptoms. All those schwannomas were at the lower thoracic region.

The main diagnostic problem in our cases was the clinical presentation as non-specific low back or neck pain. This symptom may be related with a silent tumor, and thus warrants further investigation including laboratory screening along with the imaging of the spine. In fact, these serious investigations in those cases were launched either because of persistent complaint or after real warning manifestations. The delayed and rapid onset of abrupt lower extremity weakness and sphincter dysfunction experienced by our thoracic schwannoma patients is rare in the reported literature for patients with this location.

Patients with nerve sheath tumors generally follow an indolent clinical course related to slow tumor growth; this gradual displacement of the spinal cord causes symptoms proportionally less severe than expected from the tumor size. Back pain without other neurological signs is the most common complaint from the lumbar region. Typically, the growing schwannoma creates a sharp, stabbing pain due to the compression and resultant irritation of the nerve root in the foramen.

We had three cases of schwanna (25%) from T7 to L1, one of them presented with vague right abdominal pain and presented to emergency room twice, on the second presentation, abdominal sonography was done and it was negative and the patient discharged from the emergency room, before he came back after three weeks with sudden urinary retention following repeated coughing. In spinal lesions between T8 and T12, the patient is likely to feel pain on the surface of the abdomen or within the abdominal cavity. The corresponding dermatome to T10-T12 encompasses the umbilical region and lower abdominal region as well as both right and left flanks. In addition, the stomach, small intestine and large intestine, including the appendix, are innervated by these same levels. It has been well documented that disorders of the spine or stimulation of spinal structures can cause referred pain to other areas innervated by the same spinal segments.

Jooma and Torrens reported a 73-year-old woman with an 8-year history of lower back pain that radiated to the flank and right lower quadrant of the abdomen. After undergoing an appendectomy to remove a normal appendix and a negative intravenous pyelogram, subsequent anal sphincter failure necessitated a neurological assessment which allowed the correct diagnosis of an intradural extramedullary tumor at T10 to be made. Neinstein reported a similar case in 18-year-old man who presented with a 1.5-year history of left lower quadrant abdominal pain, left-sided flank pain and left lumbar back pain radiating to the buttocks. The correct diagnosis of a T11 schwannoma was reached after almost 1 year. Cox and Alter reported a challenging diagnosis in a 30-year old man who presented with unilateral abdominal and back pain. Despite multiple evaluations, the cause of the symptoms was not identified until 11 months after the beginning of the symptoms, when an MRI scan showed an intradural extramedullary schwannoma at the T10 level.

Patients with low thoracic or high lumbar lesions with unusual presentations and late neurologic symptoms may experience a significant delay in diagnosis and treatment of their tumor. Asahara and Kawai reported that most delays in diagnosis occur for lumbar schwannomas but early diagnosis and intervention improved the clinical outcome for all schwannomas.

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Jorgensen and Fossgreen suggest somatovisceral reflexes, which may be activated by nerve root irritation at the intervertebral foramina, as a connection between abdominal pain and abnormalities in the lower thoracic spine.18

Although MRI has improved the diagnosis of spinal cord tumors, the precise histologic diagnosis cannot be made with radiographic studies alone. Tissue diagnosis is required to establish diagnosis in most spinal cord tumor cases. The presence of solitary schwannoma deserves complete MRI examination of the neuroaxis due to its multiple origins, even in the absence of neurofibromatosis.25 No multiple schwannomas were reported in this series.

Schwannomas are mostly solid or heterogeneous solid tumors6 and the previous reports have described the MR imaging characteristics of spinal schwannomas. They are typically hypointense relative to the cord on T1-weighted MR images and hyperintense on T2-weighted images24. Virtually all schwannomas enhance after administration of contrast material.31

They typically show homogeneous or heterogeneous enhancement and that are variably hyperintense on T2-weighted magnetic resonance (MR) images.27 Ten of our cases (83%) showed heterogeneous and peripheral enhancement. Two (17%) showed intense homogeneous enhancement without any secondary changes and could not be distinguished from being meningioma. Friedman and his coworkers reviewed seven cases of spinal schwannoma and found heterogeneous enhancement in all cases. Peripheral enhancement was described in five of seven lesions, which, according to them, should suggest the diagnosis of schwannoma.12

Three of our cases (25%) had multiple areas of cystic degeneration and two of them showed peripheral pattern of enhancement and enhanced internal septations. Varma and his colleagues described a target pattern with a peripheral hyperintense rim and central low intensity corresponding to peripheral myxomatous tissue and central fibrocollagenous tissue. The tumors may undergo rare cystic degeneration, hemorrhage, or xanthomatous changes.39

Various theories have been proposed to explain the cystic changes occurring in schwannomas. They may be inhomogeneous on T2-weighted images with focal areas of hyperintensity and hypointensity corresponding to cyst formation, hemorrhage, dense cellularity, or collagen deposition. Degeneration of the Antoni B portion of a neurinoma can result in cyst formation and may then progress to form a larger cyst. Also, central ischemic necrosis can be caused by tumor growth resulting in cyst formation within the tumor.31

Too many reports in the literature of cases with acute cervical and thoracic cord compression secondary to infarction rather than hemorrhage. Stepanov and his colleagues postulate that the lack of enhancement was due to absent perfusion within the cystic degeneration of the tumor.37 Shrier and his coworkers added that lack of enhancement was due to absent perfusion within the acutely infarcted tumor, in conformity with the microscopic findings indicating arterial thrombosis and marked venous congestion. It is likely that swelling of the lesion as a consequence of infarction resulted in acute compression of the cord.36

Some authors recommended complete excision of this benign but locally aggressive tumor, and sacrifice of the nerve root, because they consider that the nerve root is nonfunctional and the neurological status of the patient will not be compromised. Additionally inadequate removal of the tumor leads to an increased risk of recurrence, which is more difficult and dangerous to treat at a later stage.33 Kim and his coworkers supported this assumption that the involved nerve roots are nonfunctional at the time of surgery and the risk of further neurological deficit after sacrificing these nerve roots is small. They prefer complete excision of the tumor, even if this entails the sacrifice of the adherent nerve root.31 On the other hand, we and others supported preservation of the nerve root to avoid any added neurological deficit. Moreover, Kotura and his colleagues supported preservation of the nerve root, even if the tumor is not resected completely because of the risk of neurological deficit.25

Spinal cord and nerves function could be adequately monitored by combining SEPs and MEPs, particularly in patients with preoperative neurological deficits15. Unfortunately, both centers of our series have not equipped with intraoperative neurophysiological unit. Chen and his coworkers used somatosensory-evoked potentials (SEPs) and motor-evoked potentials (MEPs) of both upper and lower extremities and EMG of upper extremities were performed for cervical schwannomas. SEPs and MEPs of lower extremities and EMG of lower extremities and sphincter ani were performed for the dorsal and conus medullaris. They concluded that the intraoperative neurophysiological monitoring can reduce the rate of neurological complications for schwannomas originated from spinal eloquent areas and can help guide which nerve can be sacrificed and which one should be preserved.42

The other problem one faces in the management of these tumors is the post excision instability of the spine. Review of the literature revealed that surgical resection of the cauda equina tumors produced an unstable spine in almost half of the cases. We believe that this percentage is too high. We did adequate and accurate preoperative planning for each facet with the conventional and multislice reformatted CT to avoid iatrogenic instability. The laminectomy extent was quite wide in almost half of the cases. We believe that this percentage is too high. We did adequate and accurate preoperative planning for each facet with the conventional and multislice reformatted CT to avoid iatrogenic instability. The laminectomy extent was quite enough to expose and resect the mass. Moreover, we preserved the facets in all our cases except one because of the wide laminectomy and removal of medially rotated facets causing significant segmental stenosis.
Another young lady had large schwannoma underwent multiple cervical laminectomy who might need fusion in the future. However, the cervical curvature is stable for almost three years without any kyphosis tendency.

The degree of kyphosis after laminectomy is highly correlated with removal of facet joints. Kim and his coworkers reported that the osteoplastic laminoplasty prevent postoperative spinal deformities after removal of spinal cord tumors in 16 cases of laminoplasty compared with 89 cases of laminectomy. Moreover, Kawahara and his colleagues supported that by performing laminoplasty for spinal cord tumors in 24 patients.

When the long-term results were investigated in the literature, the healing and mortalities of the schwannomas that were located in the lumbosacral region were better. Clinical patterns of the patients were generally stable and the malignant transformation rates were relatively low.

The goal of the treatment for spinal cord and cauda equina tumors is to resect the lesion totally without injuring the spinal cord, cauda equina, or spinal nerve roots, or exacerbating the patients' neurologic deficit. However, we eventually need to re-operate on some patients because of tumor recurrence. In this series, 8% radiological recurrence with nerve preservation in median follow up time 33.8 month. Joen and his coworkers reported 5% recurrence rate in median follow up time 33.8 month. In their report, some cases have resected incompletely to preserve the relevant neurovascular structures. In case of residual tumor or early radiological recurrence, a long-term observation is needed.

Malignant tumor types such as malignant schwannoma also represent risk factors, either because of invasiveness precluding complete resection or because of intrinsically aggressive histologic features. Malignant schwannoma outcome is low with short survival. No malignant schwannoma or malignant transformation was reported in this series. Peng and his coworkers reported a case of recurrence and malignant transformation was reported in this series. Peng and his coworkers reported a case of recurrence and malignant transformation was reported in this series.

CONCLUSION

The spine surgeon should always keep in mind that in the differential diagnosis of neck or low back pain, intradural spine tumors are included and that despite complete resection, these benign extramedullary tumors present a continued risk of recurrence. We also suggest that a wide laminectomy may cause iatrogenic instability and necessitate spinal fusion. Therefore, adequate preoperative planning for extent of bony resection for each case may obviate the need for spinal fusion.

REFERENCES
