Spinal dumbbell tumors: an analysis of a series of 118 cases

HIROSHI OZAWA, M.D., PH.D., SHOICHI KOKUBUN, M.D., PH.D., TOSHIKI AIZAWA, M.D., PH.D., TAKEHIKO HOSHIKAWA, M.D., PH.D., AND CHIKASHI KAWAHARA, M.D., PH.D.

Department of Orthopaedic Surgery, Tohoku University School of Medicine, Sendai, Japan

Object. The authors analyzed a series of 118 cases of spinal dumbbell tumors to elucidate the feature of the tumors.

Methods. Of 674 cases of spinal cord tumors, the incidence of dumbbell tumors was studied. The tumors were analyzed, and the authors focus on the distribution of age and sex, the pathological diagnoses, their locations, Eden classification, and the surgical methods used.

Results. The incidence of dumbbell tumors was 18%. The mean patient age was 43 years, which was younger than that for all spinal cord tumors (mean 50 years). There were 11 patients younger than 10 years of age. The rate of dumbbell tumors in the cervical spine was significantly higher than that of all spinal cord tumors. Fifteen (18%) of the 81 schwannomas were observed in the C-2 nerve root, thus having a higher incidence than those in the other nerve roots. In 99 cases (84%), the tumors were removed through a hemilaminectomy with or without a facetectomy and posterior fusion. Of 118 cases, 69% of the tumors were schwannomas, and malignant tumors were found in 15 cases (13%). Seven (64%) of 11 patients younger than 10 years of age had malignant tumors. Three patients older than 10 years of age had malignant tumors, thus accounting for 2.8% of the 107 older patients.

Conclusions. The incidence of dumbbell tumors was 18%, and they are not uncommon. Malignant dumbbell tumors were more common in children younger than 10 years of age than in older patients.

KEY WORDS • dumbbell tumor • incidence • spinal cord tumor

Spinal dumbbell tumors have been defined by Heuer as a group of tumors that arise along the spine. They are constricted at the point they penetrate the intervertebral foramina or dura mater and assume an hourglass (dumbbell) shape. Currently, however, the term “dumbbell tumors” does not refer to the hourglass shape but is used as a conceptual term meaning separate tumors that connect and have two or more separate regions such as intradural space, epidural space, and locations outside the paravertebral space.

Because of their varied locations, dumbbell tumors have features, clinical symptoms, and pathological characteristics different from common intradural extramedullary tumors, and therefore, their surgical treatment is also different. Although dumbbell tumors have been managed as extraordinary tumors in the spinal cord, they are not uncommon. In this study, we describe the features of dumbbell tumors.

Clinical Material and Methods

Between 1988 and 2002, 674 spinal cord tumors were treated surgically at our hospital and affiliated hospitals. The mean patient age was 50 years (range 6 months to 92 years). The patients included 350 males (52%) and 324 females (48%).

The incidence of the dumbbell tumor was investigated among the spinal cord tumors. The dumbbell tumors were analyzed, and we focused on the distribution of age and sex, the pathological diagnoses, their locations, Eden classification, and the surgical methods used.

Results

Of 674 spinal cord tumors, there were 33 intramedullary tumors (4.9%), 503 intradural extramedullary tumors (74.6%), 20 epidural tumors (3.0%), and 118 dumbbell tumors (17.5%). The mean age of the patients with dumbbell tumors was 43 years (range 6 months to 87 years), which was younger than that for all 674 spinal cord tumors. When stratified by age, the patients between 51 and 60 years old made up the largest group with dumbbell tumors (Fig. 1). Eleven patients younger than 10 years of age had dumbbell tumors. There were 65 males (55%) and 53 females (45%).
The pathological diagnoses included 81 schwannomas (69%), 14 neurofibromas (12%), nine neuroblastomas/ganglioneuromas (8%), six meningiomas (5%), and two hemangiomas (2%). Six tumors (5%) were of miscellaneous diagnoses, including an angiolipoma, a paraganglioma, a malignant peripheral nerve sheath tumor, a malignant lymphoma, a melanoma, and a rhabdomyosarcoma. Neurogenic tumors consisting of schwannomas and neurofibromas accounted for 80% of the dumbbell tumors. One schwannoma and two neurofibromas involved additional intradural extramedullary tumors.

The spinal cord tumors appeared more commonly in the thoracic and lumbar spine than the cervical spine (Fig. 2). In contrast, the dumbbell tumors occurred most commonly in the cervical spine (44%), followed by the thoracic spine (27%) and the lumbar spine (21%). According to Eden classification (Fig. 3), 9% of tumors were classified as Type 1, 33% as Type 2, 53% as Type 3, and 5% as Type 4. The tumors classified as Type 3 were most frequent. In the cervical spine, Type 2 was most frequent; however, in the thoracic spine, Type 3 was most frequent. In the schwannomas, Eden Type 3 accounted for 48% and was most frequent. In the neurofibromas, Type 2 accounted for 52% of the lesions. All neuroblastomas and ganglioneuromas were Type 3. In the meningiomas, there were two Type 2 tumors and two Type 3 tumors. The Type 3 meningiomas had been recurrent at the epidural space and paravertebral region after excision of the intradural tumors.

We investigated tumors arising in nerve roots in 81 schwannomas and 14 neurofibromas (Fig. 4). More tumors arose from cervical and lumbar nerve roots than those from the thoracic nerve roots. There were 17 tumors (18%), including 15 schwannomas (19%) and two neurofibromas (14%), derived from the C-2 nerve root, which was the largest number among all nerve roots.

A variety of surgical methods was used. The majority of the tumors (97 of 118 cases; 82%) were excised through the posterior approach (Fig. 5). In 18 cases (15%), tumors in the paravertebral space were excised through the anterior approach after excision of tumors in the spinal canal through the posterior approach. Three tumors were excised through the anterior approach. Of 115 cases in which the posterior approach was used, a hemilaminectomy was performed in 99 cases, and a laminectomy was performed in 16 cases. In 55% of cases in which a hemilaminectomy was performed, the tumors were excised by a combination of a hemilaminectomy and facetectomy. After a longitudinal midline skin incision, the fascia and paravertebral muscle were dissected subperiosteally from the spinous articulations.

Fig. 1. Bar graph showing the age distribution of the patients with dumbbell tumors, indicating that the largest number of tumors occurred in patients between 51 and 60 years of age. Quite a few patients younger than 10 years old were also observed. N = number of patients.

Fig. 2. Bar graph. The spinal cord tumors appeared more commonly in the thoracic and lumbar spine. In contrast, the dumbbell tumors occurred most commonly on the cervical spine.

Fig. 3. Diagrams of Eden classification. The Type 3 tumors were the most frequent.
process and lamina. Using a high-speed drill, a hemilaminectomy and unilateral facetectomy were performed in Eden Types 2 and 3 tumors. Next, the tumor at the epidural and paravertebral spaces was pulled away from the dural tube and excised. The dura was opened, and the intradural lesion was excised in the Type 2 tumors. Rogers posterior wiring was performed after removal of interspinous and supraspinous ligaments for the stability of the spine. The contralateral facet fusion was added (Fig. 6). In the Eden Type 1 tumor, the spinal fusion with Rogers posterior wiring and facetectomy was not performed, because the tumor was excised without a total removal of articular process, and the interspinous and supraspinous ligaments were preserved. In a few cases in the lumbar dumbbell tumors, posterolateral fusions without any instrumentation were performed after the excision of the tumors (Fig. 7). Instrumentation was performed in three cases because of extensive vertebral destruction.

All 17 tumors in the C1–C2 space were excised en bloc through removal of one half of the C-1 posterior arch and a C-2 hemilaminectomy (Fig. 8). Of 34 cases between C-3 and C-7, tumors in the paravertebral space extended to the brachial plexus and were excised through an anterior approach; the tumors in the spinal canal were excised posteriorly in six cases. In seven tumors in the thoracic spine, the proximal ribs were removed for excision of the tumors located in the paravertebral space by the combination of a hemilaminectomy and a facetectomy. The recurrent meningiomas and the hemangiomas in the thoracic spine were excised using a laminectomy. Of five Eden Type 4 tumors in the lumbar spine, three were excised by a lateral fenestration, in which the lateral part of lamina was removed.

Eleven patients younger than 10 years old at the time of surgery were reviewed (Table 1). All of the cases were classified as Eden Type 3. Eight cases were neuroblastomas/ganglioneuromas, and the others included one schwannoma, one meningioma, and one rhabdomyosarcoma. There were two tumors in the cervical spine, four in the thoracolumbar level, three in the lumbar spine, and two in the sacral spine. Neuroblastomas and ganglioneuromas were

![Bar graph showing the number of tumors arising from nerve roots in 81 schwannomas (neurinoma) and 14 neurofibromas. There were 17 tumors (18%) that arose from the C-2 nerve root, which was the largest number among all nerve roots.](image1)

![Bar graph. A hemilaminectomy was performed in 99 cases, and a laminectomy was performed in 16 cases. In the 55% of cases in which a hemilaminectomy was performed, the tumors were excised with a combination of a hemilaminectomy and a facetectomy.](image2)
derived from the posterior mediastinum or retroperitoneal space and extended to the spinal canal through more than two foramina (Fig. 9). The mean sagittal length of the tumors in the spinal canal corresponded to a mean of 3.0 vertebrae (range 2–5 vertebrae). The tumors were excised through a hemilaminectomy with one exception, and the mean number of removed laminae was 3.0. The tumors in the foramina were excised by a facetectomy in three cases, and contralateral facet fusion and Rogers wiring were performed.

**Discussion**

The dumbbell tumor is generally understood to demonstrate a dumbbell shape. There have been various classifications of dumbbell tumors in recent years. McCormick described dumbbell tumors with significant intraspinal and paravertebral involvement and classified them into four types. Spinal cord tumors are commonly divided into four categories based on location: intramedullary, intradural extramedullary, epidural, and dumbbell. If the dumbbell tumor is simply defined as a combination of intraspinal and paravertebral tumors, tumors with intradural and intraforaminal involvement or with intraforaminal and paravertebral involvement would not be included in any of the categories.
Spinal dumbbell tumors

FIG. 8. Sagittal (left) T1-weighted Gd-enhanced and axial (upper right) MR images demonstrating a malignant dumbbell tumor (malignant peripheral nerve sheath tumor) at C-2 to C-3. A computed tomography scan obtained after surgery (lower right) showing the hemilaminectomy and facetectomy. Apparent bone destruction by the malignant tumor was not observed.

Although the pathogenesis of dumbbell tumors is still unknown, the following characteristics of tumor development were suggested from this study.

First, tumors such as neuroblastomas and ganglioneuromas observed in pediatric patients were derived from the posterior mediastinum or retroperitoneal space and extended to the spinal canal through the foramina. The tumors, such as meningiomas, located in intradural and epidural spaces were derived from the dura mater and extended into both spaces. Therefore, dumbbell tumors can arise either outside or inside the spinal canal or epidural or intradural spaces and extend to other regions through the foramen or root sleeve. Otherwise, the tumor occurring in the foramen or dura mater extends to both sides.

Second, in neurofibromas, multiple tumors arose in the intradural and epidural spaces from one nerve root. Multiple tumors that occurred at the same time in different regions such as the paravertebral region or epidural or intradural spaces would form a dumbbell tumor.

Finally, in dumbbell tumors of schwannomas and meningiomas observed in pediatric patients, the tumors might have been present before birth. If the tumors occurred in early fetal life, the dumbbell tumors might be caused by constriction from the dura mater and vertebral bone during development.
Of the 118 tumors, 10 were malignant (8.5%): six neuroblastomas and one each of the following: malignant peripheral nerve sheath tumor, malignant lymphoma, melanoma, and rhabdomyosarcoma. Seven malignant tumors were observed in children younger than 10 years, thus accounting for 64% of the 11 pediatric patients, whereas three cases were observed in patients older than 10 years of age, accounting for 2.8% of the other 107 cases. In children, the incidence of malignant dumbbell tumors was higher than that in adults. In general, a malignant tumor adjacent to bone is likely to destroy the bone, because the tumor rapidly grows and infiltrates the bone. A vertebral metastatic tumor often destroys pedicles and infiltrates the epidural space. The malignant peripheral nerve sheath tumor, neuroblastoma, and rhabdomyosarcoma showed foraminal enlargement with sclerotic margins similar to those in benign dumbbell tumors. The imaging findings did not help in distinguishing between benign tumors and malignant tumors. The malignant tumors in this study were not expected to grow as rapidly, given that a significant degree of bone destruction did not occur.

In a large number of cases, the dumbbell tumors were excised through a hemilaminectomy and a facetectomy. The hemilaminectomy combined with the facetectomy had a great advantage for excising the dumbbell tumor. Because most tumors were located unilaterally in the spinal canal and paravertebral space, the tumors could be excised easily from the posterolateral large space provided by the hemilaminectomy and facetectomy. In addition, the spinal stability can be reconstructed easily by Rogers wiring and contralateral facet fusion, because the hemilaminectomy and facetectomy can minimize damage to spinal stability by leaving the spinous process, supra- and intraspinous ligaments, and contralateral facet joint.

Unlike older patients, those younger than 10 years old suffered less commonly from schwannomas and more from various tumors such as neuroblastomas, ganglioneuromas, meningiomas, and rhabdomyosarcoma. Neuroblastomas and ganglioneuromas are child specific, and they are derived from the posterior mediastinum or the retroperitoneal

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**TABLE 1**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Histology</th>
<th>Level</th>
<th>Bone Change</th>
<th>Op Approach</th>
<th>Outcome (follow-up yrs)</th>
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<tr>
<td>1</td>
<td>3, M</td>
<td>meningioma</td>
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<td>HLM, ULF, &amp; PF</td>
<td>NED (18)</td>
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<td>C5–T5</td>
<td>—</td>
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<td>NED (2)</td>
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<tr>
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<td>3, F</td>
<td>rhabdomyosarcoma</td>
<td>T8–10</td>
<td>foraminal enlargement</td>
<td>HLM</td>
<td>NED (5)</td>
</tr>
<tr>
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<td>3, F</td>
<td>ganglioneuroma</td>
<td>T10–L2</td>
<td>vertebral scalloping</td>
<td>LM, ant</td>
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<td>—</td>
<td>HLM, ant</td>
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</tr>
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<td>—</td>
<td>HLM</td>
<td>NED (6)</td>
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<td>—</td>
<td>HLM</td>
<td>NED (5)</td>
</tr>
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<td>L2–4</td>
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<td>L3–4</td>
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<td>remission (11)</td>
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<tr>
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<td>S2–3</td>
<td>foraminal enlargement</td>
<td>HLM, ant</td>
<td>remission (11)</td>
</tr>
</tbody>
</table>

* All children had Type 3 tumors according to Eden classification. Abbreviations: ant = anterior exposure; DOD = died of disease; HLM = hemilaminectomy; LM = laminectomy; NED = no evidence of disease; PF = Rogers wiring and posterior fusion; ULF = unilateral facetectomy.

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![Fig. 9. Sagittal T1-weighted Gd-enhanced MR image (left) and intraoperative photograph (right) obtained in a 7-month-old infant with a neuroblastoma between C-6 and T-5.](image)

*Left:* A large tumor is seen in the spinal canal and mediastinal space (arrows). *Right:* The dural tube and nerve roots were restored after the excision of the tumor by means of the hemilaminectomy.
space and extend to the spinal canal through more than two foramina. The excision of these tumors requires a number of laminectomies because the sagittal length of the tumors is long. Therefore, because of the way the patient’s body may develop, postoperative deformity may occur. It was necessary that the surgery for patients younger than 10 years was less invasive to prevent postoperative deformity. The hemilaminectomy and facetectomy combined with Rogers wiring and contralateral facet fusion are expected to supply these demands.

Conclusions
The incidence of dumbbell tumors was 18% of 674 spinal cord tumors. The rate of dumbbell tumors in the cervical spine was significantly higher than that of the 674 spinal cord tumors. Fifteen (18%) of 81 schwannomas were observed in the C-2 nerve root, thus having a higher rate than those in the other nerve roots. Of the tumors, 69% were schwannomas, and malignant tumors were found in 10 cases (8.5%). The malignant dumbbell tumors accounted for 64% of cases in pediatric patients and 2.8% in adult patients.

References

Manuscript submitted April 12, 2007. Accepted August 15, 2007. Address correspondence to: Hiroshi Ozawa, M.D., Department of Orthopaedic Surgery, Tohoku University School of Medicine, 1-1 Seiryoumachii, Aoba ku, Sendai 980-8574, Japan. email: ozw@mail.tains.tohoku.ac.jp.