Before the introduction of high-resolution MR imaging in the preoperative diagnosis of spinal lesions, unusual sequestered disc fragments were diagnosed only during surgery.\textsuperscript{5,14,15,19,33} Despite the fact that atypically located disc herniations are rare, even today they are frequently misinterpreted as a tumor.\textsuperscript{3,6,8,22,29} There are no particular clinical features allowing clear differentiation between patients with atypically located disc herniations and those with tumoral lesions. Only a few MR imaging findings can help to increase the preoperative diagnosis of herniations,\textsuperscript{6,10,12,39,40} but the appearance of these findings remains inconsistent.\textsuperscript{22,29}

Some intradural lesions are related to dense adhesions between the ventral dura mater and the posterior longitudinal ligament.\textsuperscript{2,10,19,26} These adhesions can apparently result from either repeated minor trauma or prior surgery.\textsuperscript{2,28,41} Taking into account that sequestered disc fragments can occasionally migrate even to the posterior epidural space,\textsuperscript{6,13,21,25,37} the differential diagnosis includes not only diverse neoplasms but also other epidural processes such as synovial cysts, hematomas, and inflammatory lesions.\textsuperscript{13}

To evaluate additional characteristics of these atypical cases, we designed a retrospective analysis of recently treated patients with a confirmed histological diagnosis of disc herniation. The frequency, management, and outcome of each of these cases were analyzed.

**Methods**

We performed a retrospective departmental analysis of the last 3000 surgically treated patients with a histological diagnosis of disc herniation between 2002 and 2008. This review included operative and medical reports, MR images, and outpatient charts. Admission T1- and T2-weighted transverse and sagittal sections of non-enhanced and Gd-enhanced MR images were examined for all patients. Cases with unusual MR imaging findings—unusual location, size, form, or characteristics of a spinal lesion—were individually analyzed. The uptake of contrast material (that is, peripheral rim enhancement after Gd injection), the presence of a halo of CSF isointensity suggestive of intradural disc fragment extension, and the disc space level considered to be the origin of the lesion were documented. In addition, the type and number of complementary preoperative radiological studies were evaluated.
performed in these cases (myelography and postmyelography CT scanning) as well as their utility in contributing to the preoperative diagnosis were evaluated.

The following parameters from the medical records were retrospectively reviewed: age and sex of the patient, clinical neurological status at admission, type of interventional procedure performed, and histological characteristics of the lesion. The presence of spine trauma or previously performed surgical procedures as well as the duration of symptoms was also recorded. Outcome was evaluated 1 month after all targeted rehabilitation programs were completed. Outcome categories included no improvement, improvement with complete recovery, and improvement with residual deficit. Residual neurological deficits were classified as minor, moderate, or severe.

Results

In 11 (0.4%) of the 3000 patients, the preoperative MR images of sequestered disc fragments showed unusual findings. Clinical and radiological data for these patients are summarized in Table 1. Among these patients—6 women and 5 men, with an age range of 29–83 years—were found diverse, unusually located heterogeneous masses with a low-intensity or isointense signal on T1-weighted images as well as a low signal (4 patients) or high signal (7 patients) intensity on T2-weighted images, relative to the intraspinal structures. Although there was no typical tumor enhancement after Gd administration in these cases, diverse differential diagnoses, including abscess, hematoma, synovial cyst, and various neoplasms, had been preoperatively considered. Intradural disc fragments showed a high-intensity to isointense signal on MR imaging. In the patient in Case 1, preoperative T2-weighted MR images showed a 15-mm, left-sided, posterolateral, high-intensity to isointense space-occupying lesion at the C-7 level. A slight nonhomogeneous peripheral rim enhancement was present after Gd injection. Disc protrusions were observed at the C5–6 and C6–7 levels but were not clearly related to the intraspinal lesion. Possible radiological differential diagnoses included a teratoma and an old capsulated hematoma (Figs. 1A and B and 2A). During surgery, following a longitudinal dura mater incision at the C-7 level on the left side, a 1 × 0.8–cm intradural disc fragment was extirpated in 1 piece (Fig. 2B and C). The arachnoid membrane was not perforated. The patient experienced pain relief immediately after surgery. The postoperative radiological controls are shown in Figs. 1C and D and 2D.

Similar preoperative MR imaging findings were observed in the patient in Case 3. The T2-weighted MR images obtained in this patient showed a 19-mm, left-sided, posterolateral heterogeneous intradural lesion with high signal intensity at the T12–L1 level (Fig. 3A and B). Slight diffuse Gd enhancement and the absence of extruded disc fragments in neighboring disc spaces made an accurate diagnosis difficult. The presence of isointensity from a halo of CSF was suggestive of the intradural location of this mass. The preoperative radiological differential diagnosis was meningioma. During surgery, the absence of adhesions between the dura, the nerve roots, and the suspected neoplasm was noteworthy. The intradural sequestered disc fragment was gross totally excised (Fig. 3C). Postoperative MR imaging examination confirmed the complete removal of the lesion (Fig. 3D).

Epidural lesions often showed low signal intensity on MR images. The T2-weighted MR images obtained in the patient in Case 2 showed a 12-mm, right-sided, posterolateral, low-signal-intensity space-occupying lesion at the L3–4 level. No rim enhancement was observed after Gd injection. Disc herniation and an extruded ascendant fragment at the L4–5 level on the left side could also be identified (Fig. 4). The preoperative diagnosis was a left-sided disc herniation at L4–5 and an unclear right-sided, posterolateral, epidural, benign space-occupying lesion at L3–4. During surgery, a free sequestered disc fragment scarcely attached to the dura mater was removed at the L3–4 level.

Several additional neuroimaging examinations, including myelography (4 cases) and CT (8 cases), did not clearly improve the accuracy of the preoperative diagnosis. A progressive spinal neurological deficit within the last 3 months before admission (3 bladder dysfunctions, 1 incomplete paraparesis, and 7 root compression syndromes) was documented in all patients. In 7 patients, the presence of chronic back pain symptoms lasting from 4 weeks to 3 months and corresponding to the level of the radiological lesion was confirmed by the anamnesis. Disc fragments migrated to the posterior or posterolateral spinal space in 8 cases and extended into the dural sac at the level of the damaged disc space in 3 of them. In 3 cases, the fragments were at least 1 level distant from the original disc spaces. Disc fragments were located in the cervical (1 case), thoracic (2 cases), and lumbar (8 cases) spine. All lesions were completely removed at surgery. Additional discectomy was required in only 4 patients. The patients experienced acute postoperative relief of their symptoms along with improvement in their neurological deficits. Complete recovery was attained in 8 patients and a minor neurological deficit remained in 3. Magnetic resonance imaging reexaminations performed 4–8 days after surgery confirmed the complete removal of the lesions.

Discussion

The spinal canal migration of disc fragments simulating intraspinal tumoral space-occupying lesions has been documented with only isolated case reports.\textsuperscript{3,6,8,21,22,29} Today, the improved anatomical definition of MR imaging increases the amount of preoperatively registered data. Even with this technology, however, some disc fragments still can be mistaken for other more common epidural and intradural benign lesions or neoplasms. The absence of accompanying disc space protrusions on MR images carries a particular risk for misdiagnosis. Some fragmented disc lesions can even show peripheral or diffuse enhancement related to their inflammatory secondary reaction. In our cases, atypical sequestered disc herniations demonstrated a heterogeneous low-intensity to isointense signal relative to the intraspinal structures on T1-weighted MR images as well as low (4 cases) or high signal (7 cases) intensity.
TABLE 1: Summary of clinical, treatment, and outcome data in 11 patients with MR imaging findings simulating spinal tumors

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Fragment Location/Level</th>
<th>Differential Diagnosis</th>
<th>Symptoms &amp; Duration</th>
<th>Previous Surgery/Trauma</th>
<th>T2-Weighted MRI Findings</th>
<th>Op Approach/Discectomy</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M, 72</td>
<td>intradural, posterolat/C6–7</td>
<td>neoplasm hematoma</td>
<td>C-7 radiculopathy, CR/6 wks</td>
<td>no HSI–ISI, PRE</td>
<td>hemilaminect</td>
<td>IP, complete recovery</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>M, 83</td>
<td>extradural, posterolat/L3–4</td>
<td>synovial cyst</td>
<td>L-5 radiculopathy, LBP/2 mos</td>
<td>no LSI</td>
<td>hemilaminect undercutting/AD</td>
<td>IP, complete recovery</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>F, 58</td>
<td>intradural, posterolat/T12–L1</td>
<td>meningioma</td>
<td>L-5 radiculopathy, LBP/3 wks</td>
<td>no HSI–ISO, SDE, halo of CSF</td>
<td>partial laminotomy</td>
<td>IP, complete recovery</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>F, 56</td>
<td>intradural, lateral/L1–2</td>
<td>schwannoma</td>
<td>incomplete paraparesis, LBP/12 days</td>
<td>no HSI, halo of CSF</td>
<td>hemilaminot, facetectomy</td>
<td>IP, minor residual deficit</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>M, 45</td>
<td>extradural, posterolat/L4–5</td>
<td>neoplasm</td>
<td>L-5 radiculopathy, LBP/4 wks</td>
<td>no LSI</td>
<td>partial laminotomy</td>
<td>IP, complete recovery</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>M, 29</td>
<td>extradural, lateral/T8–9</td>
<td>neoplasm</td>
<td>bladder dysfunction, BP/3 wks</td>
<td>no HSI, SDE</td>
<td>hemilaminect, partial facetectomy/AD</td>
<td>IP, complete recovery</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>F, 45</td>
<td>extradural, anterolat/L2–3</td>
<td>abscess</td>
<td>L-3 radiculopathy, BP/2 mos</td>
<td>yes LSI, PRE</td>
<td>partial laminotomy/AD</td>
<td>IP, minor radicular residual deficit</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>M, 67</td>
<td>extradural, posterolat/L4–5</td>
<td>synovial cyst, neoplasm</td>
<td>L-4 radiculopathy, LBP/3 mos</td>
<td>no LSI, PRE</td>
<td>hemilaminot, partial facetectomy</td>
<td>IP, complete recovery</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>F, 60</td>
<td>extradural, posterolat/L5–S1</td>
<td>epidural metastasis</td>
<td>bladder dysfunction, LBP/2 mos</td>
<td>no HSI, SDE</td>
<td>hemilaminect undercutting</td>
<td>IP, complete recovery</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>F, 59</td>
<td>extradural, posterolat/L2–4</td>
<td>hematoma</td>
<td>L-4 radiculopathy, BP/4 wks</td>
<td>yes HSI</td>
<td>2 levels hemilaminot/AD</td>
<td>IP, complete recovery</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>F, 71</td>
<td>intradural, posterolat/L1–2</td>
<td>meningioma</td>
<td>bladder dysfunction, BP/9 wks</td>
<td>yes HSI, SDE, halo of CSF</td>
<td>hemilaminect</td>
<td>IP, transient urinary retention</td>
<td></td>
</tr>
</tbody>
</table>

* AD = additional discectomy; BP = back pain; CR = cervical radiculopathy; hemilaminect = hemilaminectomy; hemilaminot = hemilaminotomy; HSI = high signal intensity; IP = improvement; ISI = intermediate signal intensity; ISO = isointensity; LBP = lower BP; LSI = low signal intensity; PRE = peripheral rim enhancement; SDE = slight diffuse enhancement.
Unusual sequestered disc fragments simulating spinal tumors

on T2-weighted MR images depending on their location (intra- or extradural) and time of evolution. Gadolinium enhancement was observed in only 7 patients having a well-defined granulation response.

Extruded disc fragments can migrate posterior to the thecal sac or even be located inside the dura mater. Most of the literature details cases with cervical intradural disc fragments showing a clear relationship with a damaged disc space. To the best of our knowledge, our study includes the first cervical intradural and posteriorly migrated disc simulating a tumor mass. The fragment migration patterns of atypically located disc herniations are generally limited by the attachments of the posterior longitudinal ligament and its associated midline septum and peridural or lateral membrane. Most symptomatic intradural disc migrations in the lumbar spinal canal have been noted to have a lateral position with resultant nerve root irritation. Prestar and Schattke have found in 2 patients that the free disc fragments penetrated the dural sac from the axilla of the nerve root. These and other authors have speculated that a weakness in the dura mater ventrally and at the axilla of the nerve root was the possible origin of these lesions. Although caudal, rostral, and lateral migrations of disc fragments are common, posterior migration of an extruded disc fragment with spinal cord compression is a very uncommon event.

Posterolaterally migrated disc fragments lying on the epidural contralateral cephalic spinal space also have been rarely reported. Bonaroti and Welch and Dösoğlu et al. have described 2 patients with an acute cauda equina syndrome. Magnetic resonance imaging in both cases revealed a posterior epidural mass, which was hypointense on T1- and T2-weighted images. Postgadolinium imaging showed rim enhancement of these lesions. Although some authors have found that contrast-enhanced MR imaging is useful in differentiating a herniated disc from disc space infections and tumors, accurate diagnoses often can be made only during surgery. Choi et al. have described 2 additional findings: the so-called hawk-beak sign as well as the abrupt loss of continuity in the posterior longitudinal ligament on axial imaging as potential signs of intradural disc herniations. However, as indicated by Yamashita et al., only the result of examinations using Gd-enhanced MR imaging can help to increase the certainty of the preoperative diagnosis of sequestered disc lesions. In their report, histological examination confirmed that MR imaging defects were sequestered disc material covered with vascularized granulation tissue. The intense peripheral enhancement of intra- and some extradural defects on Gd-enhanced MR images was related to the accumulation of contrast material within the vascularized granulation tissue surrounding the avascular sequestered disc material. Unfortunately, this enhancement seems to depend on the time elapsed since the occurrence of intradural disc herniation and therefore was not always present in our cases. This sign was present in 4 patients with intradural and 3 with epidual disc fragments having more than 3 weeks and 2 months of development, respectively.

Intradural disc fragments produce earlier medullary and radicular compression syndromes. Their incidence has been reported to be 0.27% of all herniated discs. Disc fragments inside the radicular sheath also have been related to intradural migration mechanisms. Mut et al. have classified intradural disc herniations into 2 subtypes: Type A, herniation of a disc into the dural sac; and Type B, herniation of a disc into the dural sheath in the preganglionic region of the nerve root (intraradicular). Their classification was based on spinal dural anatomy. Most of the reported cases simulating an intradural extramedullary tumor are Type A lesions. The exact mechanisms of the dural tear are unknown. Because several of the patients described in the literature underwent
prior surgery at the level of the subsequent intradural herniation, it has been postulated that dense posttraumatic or postoperative adhesions are responsible for this particular type of lesion. In such cases, large ragged dural tears were often intraoperatively identified and directly related to the underlying disc space.18,22 However, none of the patients in our study had undergone previous surgery, and only 3 pa-

TABLE 2: Magnetic resonance imaging differential diagnosis of a sequestered disc lesion*

<table>
<thead>
<tr>
<th>Lesion Type</th>
<th>Enhanced</th>
<th>Nonenhanced</th>
<th>Useful Additional MRI Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>sequestered disc lesions</td>
<td><em>rim enhancement produced by vascularized granulation tissue covering the sequestered disc can be observed after several wks of evolution</em></td>
<td>low to isointense signal on T1 as well as low or sometimes high intensity on T2-weighted MRI, depending on their intradural or extradural location &amp; time of evolution</td>
<td>bSSFP sequences can improve diagnosis of sequestrations in some cases</td>
</tr>
<tr>
<td>infection &amp; abscess</td>
<td>identify areas of active disease but can be nonspecific for infection</td>
<td>T2 hyperintensity &amp; high signal on DWI w/ reduced ADC in spinal epidural abscess</td>
<td>3D COSMIC or MERGE sequences may favor infection over inflammatory or neoplastic etiologies</td>
</tr>
<tr>
<td>vascular</td>
<td>MRA and 3T images provide the conspicuity for reliable characterization of the lesion</td>
<td>tiny hypointensities (flow voids) in presence of dAVF on T2-weighted MRI</td>
<td>use of PROPELLER FR-FSE technique to reduce CSF pulsation artifacts</td>
</tr>
<tr>
<td>tumor</td>
<td>Intradural extradural lesions displace the spinal cord and enlarge the subarachnoid space creating a CSF cap to the enhanced mass</td>
<td>chordomas classically show bright signal on T2 images with a low signal rim whereas lymphoma &amp; some metastases w/ high cellularity are characterized by a low T2 signal</td>
<td>DWI can detect altered cellular matrix of neoplastic tissues differentiating different types of mass lesions</td>
</tr>
</tbody>
</table>

* ADC = apparent diffusion coefficient; bSSFP = balanced steady-state free precession; COSMIC = coherent oscillatory state acquisition for the manipulation of image contrast; dAVF = dural arteriovenous fistula; DWI = diffusion weighted imaging; FR-FSE = fast-recovery fast spin echo; MERGE = multiple echo recombined gradient echo; MRA = MR angiography; PROPELLER = periodically rotated overlapping parallel lines with enhanced reconstruction.
of lesions including lymphoma, neurofibroma, neuroblastoma, mesothelioma, and lung cancer. Any enhancement of the spinal meninges should be considered abnormal, and primary tumors such as lung cancer, breast cancer, and melanoma can produce isolated enhancing lumps or sheets of nodular enhancement in the spinal meninges. While sagittal T2-weighted MR images provide useful information for the differential diagnosis of all of these lesions, contrast-enhanced T1-weighted and T2-weighted short-tau inversion recovery images are helpful in identifying a possible epidural abscess. Certain tumors and infections differ with regard to imaging (MR) enhanced and nonenhanced sequestered disc lesions (Table 2). Thoracic extruded discs mimicking spinal cord tumors seldom have been reported.3,19,20,23 The restricted mobility of this spinal segment could explain the reduced migration of sequestered disc fragments. As a matter of fact, the majority of intradural herniations occur at the lumbar level.24 Intradural lumbar disc fragments can be microscopically recognized through the dorsal dura mater. In all of the cases in our study as well as in several reports in the literature, the lesions produced neurological deficits within the first 3 months after the onset of symptoms; however, delayed fragment migrations are still possible. Mobbs and Steel25 have reported on a patient who presented with 3 months of L-3 pain on the right side with accompanying sensory and motor changes. Over a 24-hour period, the right leg pain disappeared and left-sided L-5 nerve root compression symptoms developed. An MR imaging examination confirmed delayed migration of the epidural mass.

Conclusions

We concluded that atypically located disc fragments are a rare event, but they must be considered preoperatively as the differential diagnosis in all patients with unclear intraspinal space-occupying lesions on MR imaging. The potential damage this benign lesion can cause highlights the importance of its correct preoperative diagnosis. A delay in surgical treatment, to perform additional invasive studies or complex surgical approaches, does not seem justified.

Disclaimer

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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Accepted March 19, 2009.
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