Magnetic resonance imaging localization with cod liver oil capsules for the minimally invasive approach to small intradural extramedullary tumors of the thoracolumbar spine

Clinical article

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Object. Accurate intraoperative localization of small intradural extramedullary thoracolumbar (T-1 to L-3 level) spinal cord tumors is vital when minimally invasive techniques, such as hemilaminectomy, are used to excise these lesions. In this study, the authors describe a simple and effective method of preoperative MRI localization of small intradural extramedullary tumors using cod liver oil capsules.

Methods. Thirty-five patients with intradural tumors underwent preoperative MRI localization the evening prior to surgery. Patients were positioned prone in the MRI gantry, mimicking the intraoperative position. Nine capsules were placed in 3 rows to cover the lesion. This localization was used to guide the level for a minimally invasive approach using a hemilaminectomy to excise these tumors.

Results. The mean patient age was 51.5 ± 14.3 years, and the mean body mass index was 24.1 ± 3.5 kg/m². Twenty-two tumors involved the thoracic spine, and 13 involved the upper lumbar spine from L-1 to L-3. The mean tumor size was 2.2 ± 1.0 cm. Localization was accurate in 34 patients (97.1%).

Conclusions. Accurate localization with the described method is quick, safe, cost-effective, and noninvasive with no exposure to radiation. It also reduces operating time by eliminating the need for intraoperative fluoroscopy.

Key Words • hemilaminection • intradural tumors • MRI localization • thoracolumbar spine • oncology • technique • cod liver oil

A ccurate intraoperative localization of intradural tumors in the thoracic and upper lumbar spine is challenging. A variety of techniques, ranging from conventional marker radiographs to neuronavigation, have been described to overcome errors that continue to occur, albeit in small numbers, in determining the correct level of spinal pathology. In a recent survey conducted to estimate the incidence of wrong-level lumbar spine surgery, Groff et al.3 noted that almost 50% of reporting surgeons had performed wrong-level lumbar spine surgery at least once in their practice. While such a survey has not been performed in patients undergoing surgery for thoracic and upper lumbar intradural tumors, it is reasonable to expect that in a small but substantial number of such patients, a wrong-level exposure has been performed. The incidence of wrong-level surgery is likely to be higher for patients undergoing a minimally invasive technique such as a hemilaminectomy or hemilaminotomy. In this report we describe the use of cod liver oil capsules in the preoperative MRI localization of intradural tumors with an emphasis on the technique, advantages, drawbacks, and outcomes in 35 patients.

Methods

Thirty-five consecutive patients with a preoperative

This article contains some figures that are displayed in color online but in black-and-white in the print edition.

Abbreviation used in this paper: BMI = body mass index.
since the lesion and the marker were always visible on the T2-weighted MR images. For the initial patients, the adhesive and the capsules were left on the skin until surgery. In later cases, after the scan had been obtained, indelible ink was used to mark the 3 rows corresponding to the 3 rows of capsules (Fig. 3). This improved patient comfort while sleeping on his or her back the night prior to the surgery. The entire process took about 10–15 minutes.

In the operating room, after intubation, the patient was turned prone with the upper limbs by his or her side to reproduce the position used in the MRI room. At surgery, a small midline skin incision was made based on the markings made the day before, and dissection was performed to expose the unilateral hemilamina or laminae. The hemilaminectomy was done using a high-speed drill (Aesculap). A perpendicular trajectory was maintained while removing bone and ligaments to expose the dura mater on the side of the lesion. After the tumor excision was done using an operating microscope, the dura was closed primarily using 7-0 Prolene (Ethicon Inc.). The patient was ambulated within a few hours after surgery and was usually discharged on the 2nd or 3rd postoperative day.

Results

Thirty-five patients with a mean age of 51.5 ± 14.3 years (range 6–80 years) were included in the study (Table 1). Twenty-two patients (62.8%) were male. The weight of these patients ranged from 18 to 84 kg, and the mean body mass index (BMI) was 24.1 ± 3.5 kg/m² (range 15.1–31.6 kg/m²). Seven tumors involved the upper thoracic spine from T-1 to T-6, 15 tumors involved the lower thoracic spine from T-7 to T-12, and 13 tumors involved the upper lumbar spine from L-1 to L-3. The mean duration of symptoms was 18 months. The mean tumor size was 2.2 ± 1.0 cm. Twenty-seven tumors were either dorsal or dorsolateral to the cord, whereas 8 tumors were ventral or ventrolateral. In all cases except one, a total excision was done. In one case of a meningioma that was near-totally excised, bits of tumor adherent to the ventral dura were left behind. The mean duration of surgery was 1.4 ± 0.8 hours. In none of the patients was it necessary to convert the hemilaminectomy into a full laminectomy.

In 34 patients (97.1%) the tumor was exposed at the correct level. There was an error of localization in one patient (2.9%) with a tumor at the T-5 level; no tumor was visualized on opening the dura. This case was early in the series, and we believe that the error resulted from a change in the position of the upper limbs between the MRI suite and the operating room. The upper limbs, which were kept on either side of the head during MRI, were kept at the side of the body during the surgery. This change in the position of the upper limbs might have led to movement of the skin on the back, leading to the error in localization at surgery. Realizing this possibility, we extended the hemilaminectomy one level above and were able to visualize the tumor and excise it completely. Since this experience, we have ensured that the arms remain at the side of the body during MRI to mimic the surgical position. One patient with a lumbar schwannoma had transient ankle weakness, which improved at the time of discharge. No other patients had any neurological worsening or CSF wound leakage. The mean duration of the postoperative in-hospital stay was 3.1 ± 1.8 days.

Discussion

Localization Using Bony Landmarks

Preoperative radiographs with opaque markers and intraoperative fluoroscopy are currently the most commonly used localization techniques for intradural pathologies of the thoracolumbar spine. The primary disadvantage of these techniques is that the intradural pathology itself is not visualized. The spinous process is used as a reference point, which in the thoracic spine is oblique and hence serves only as an approximate localizer. The pedicle–transverse process–rib junction in an anteroposterior projection is a more reproducible landmark. However, a combination of factors, such as patient size, scapular shadows, and decreased bone density, makes accurate counting of the spines with fluoroscopy difficult. Sammon et al.7 and Slotty et al.8 have suggested the use of preoperative CT-guided placement of a flexible hook-wire marker for localization of a spine level. This is an invasive procedure requiring local anesthesia, with some discomfort to the patient. Preoperative needle placement may also increase the risk of infection. Other attempts at presurgical marking include polymethylmeth-
acrylate injections or marking the tip of the vertebra with blue dye.\textsuperscript{4,5} Upadhyaya et al.\textsuperscript{10} recently described the use of 5-mm fiducial screws inserted via CT guidance preoperatively in 26 patients to avoid errors in localizing both intra- and extradural thoracic pathologies. They mentioned an additional cost of approximately $1500 and exposure to radiation as disadvantages of their technique—both of which are concerns in our practice setting. Their technique also involved an invasive procedure, which could lead to an increase in infection rates. Our technique successfully helps to overcome these issues. All of the aforementioned techniques rely on the surgeon’s ability to correlate the level of intradural pathology with the overlying bony anatomy and are prone to errors of judgment. Moreover, these procedures are not free from complications, primarily because of their invasive nature.

The use of bony landmarks may result in the need for longer incisions to ensure that an intradural mass is not missed. This defeats the very purpose of a minimally invasive procedure such as hemilaminectomy, in which small skin incisions, limited muscle dissection, and limited removal of bone and ligaments contribute to improved patient outcomes in terms of less postoperative pain, early mobilization, and reduced risk of delayed instability.

Localization Based on Visualization of the Intradural Pathology

It is obvious that localization based on direct visualization of the intradural pathology would be superior to that which uses bony anatomy. The advantages of a preoperative localization technique that eliminates the use of intraoperative fluoroscopy are the time savings and the elimination of radiation exposure to the patient as well as operating room personnel. Most importantly, it provides localization based on visualization of the intradural pathology and therefore is less likely to be erroneous.

Thomson\textsuperscript{9} first described the use of halibut liver oil capsules for MRI localization of intradural pathology. A line of capsules was placed vertically in the midline. Whether this localization method was effective in avoiding errors in the operating room was not confirmed, however. English et al.\textsuperscript{2} used tubes filled with dilute Gd and placed several of them horizontally in a vertical row along the midline during MRI. They used this technique in 5 patients with thoracic spine pathology and noted half a vertebral body height movement when the patient was moved from the supine to the prone position. (This skin movement explains the failure in one of our patients.) Again, English et al. did not document the accuracy of their technique in the operating room. Rosahl et al.\textsuperscript{6} described the use of commercially available multimodality radiographic skin markers, which are self-adhesive and easy to align, for preoperative localization based on direct visualization of the intradural pathology. These markers are visible on both CT and MRI. These authors did not provide evidence to support the effectiveness of their technique. None of the 3 reports cited actually mention the surgical approach used for the intradural tumors, and we presume that a standard laminectomy was most likely performed.

### TABLE 1: Summary of patient and tumor characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>total no. of patients</td>
<td>35</td>
</tr>
<tr>
<td>M:F ratio</td>
<td>22/13</td>
</tr>
<tr>
<td>mean age in yrs</td>
<td>51.5 ± 14.3</td>
</tr>
<tr>
<td>age range in yrs</td>
<td>6–80</td>
</tr>
<tr>
<td>mean BMI in kg/m(^2)</td>
<td>24.1 ± 3.5</td>
</tr>
<tr>
<td>BMI range in kg/m(^2)</td>
<td>15.1–31.6</td>
</tr>
<tr>
<td>mean tumor size in cm</td>
<td>2.2 ± 1.0</td>
</tr>
<tr>
<td>tumor location</td>
<td></td>
</tr>
<tr>
<td>T1–6</td>
<td>7</td>
</tr>
<tr>
<td>T7–12</td>
<td>15</td>
</tr>
<tr>
<td>L1–3</td>
<td>13</td>
</tr>
<tr>
<td>pathology</td>
<td></td>
</tr>
<tr>
<td>schwannoma</td>
<td>20</td>
</tr>
<tr>
<td>meningioma</td>
<td>11</td>
</tr>
<tr>
<td>other</td>
<td>4</td>
</tr>
<tr>
<td>mean op time in hrs</td>
<td>1.4 ± 0.8</td>
</tr>
</tbody>
</table>
MRI localization of intradural spinal tumors

We have tested the efficacy of our localization technique in the context of performing a minimally invasive hemilaminectomy, an approach that is less forgiving of an error in localizer. Moreover, we have verified the accuracy of this technique in a large group of patients with different body weights and BMIs. The technique was successfully used in 9 patients who were obese (BMI > 25 kg/m²), including 1 patient with a BMI > 30 kg/m².

Intraoperative CT and/or MRI and navigation are costly alternatives and not readily available. They also significantly increase operating room time. Cod liver oil capsules are very inexpensive, costing $0.50 for 9 capsules. Vitamin E capsules are also an alternative but are much smaller. The disposable commercially available skin markers suggested by Rosahl et al.⁵ are a good alternative but are expensive as compared with the cod liver oil capsules. The cod liver oil capsules do not produce artifacts on MRI. Neither is the patient inconvenienced by the procedure. The disadvantage of the technique is that the patient requires an additional MRI study the day before surgery. We have not confirmed the use of our technique in patients with severe scoliosis or other spinal deformities. In a recent publication, Daghighi et al.¹ described the use of nifedipine oil capsules as an MRI marker to determine the incision site for lumbar disc surgeries. However, these authors tested their technique for an extradural pathology of the lower lumbar spine where intraoperative fluoroscopy always works well.

Study Limitations

Although we used this technique successfully in our patient cohort, it has not been tested in a large cohort of morbidly obese or elderly patients in whom the skin folds over itself or is very mobile; however, we believe that simulating the operative position in the MRI gantry will significantly help to minimize localization errors even in such obese patients. Although we have used this technique as a stand-alone localization method, other surgeons might feel more comfortable using it as a supplement to the more traditional fluoroscopic techniques. We believe that its use is justified even in that role, as it is noninvasive and relatively inexpensive.

We do not recommend this localization technique for patients with thoracic disc prolapse, in whom we routinely use intraoperative fluoroscopy.

It is essential that the localization MRI be done the evening before surgery or on the morning of the surgery, which could pose a scheduling or logistical challenge in some hospitals.

Conclusions

Accurate localization with the described method is quick, safe, cost-effective, and noninvasive with no exposure to radiation. It also reduces operating time if the surgeon is comfortable in using it as a stand-alone localization technique and avoids intraoperative fluoroscopy.

Acknowledgments

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Disclosure

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

Author contributions to the study and manuscript preparation include the following. Conception and design: Rajeshkhar. Acquisition of data: Turel. Analysis and interpretation of data: Rajeshkhar. Drafting the article: both authors. Critically revising the article: Rajeshkhar. Reviewed submitted version of manuscript: both authors. Approved the final version of the manuscript on behalf of both authors: Rajeshkhar.

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