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Differentiation between Intramedullary Spinal Cord Tumors and Multiple Sclerosis on Targeted T1-weighted Magnetic Resonance Imaging

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Abstract In patients presenting with acute transverse myelopathy, it is clinically important to differentiate between intramedullary tumors and multiple sclerosis (MS) before deciding on a therapeutic strategy. However, it is sometimes difficult to differentiate between these two disorders on magnetic resonance (MR) imaging because they often show hyperintensity on T2-weighted images and isointensity on T1-weighted images. In these cases, radiological findings on T1-weighted images provide little useful information for the differential diagnosis. Therefore, in this study isointense images on T1-weighted imaging were reevaluated by changing and adjusting the window-level and -width focused on the intramedullary region of interest. The demarcation of the lesions became apparent in patients with intramedullary tumors, whereas similar findings were not observed in patients with multiple sclerosis. We emphasize that changes of window-level and -width focused on the region of interest provides us additional information about the spinal cord that cannot be obtained with the conventional MR imaging.

Introduction

Since the development of MR imaging, it has become easy to identify intramedullary changes within the spinal cord. T2-weighted images are best suited for the detection of intramedullary lesions; however, nonspecific findings such as tumors, demyelination, and edema are often shown in the hyperintense area. T1-weighted images provide valuable information on morphologic characteristics, but spinal cord tumors and MS often show as isointense to normal spinal cord and, hence, are uninformative. Therefore even with conventional MR imaging, it is often difficult to differentiate between intramedullary spinal cord tumor and MS in patients with acute transverse myelopathy in spite of histological differences. Because in the early stage the differential diagnosis is very im-

portant for deciding on a therapeutic strategy, clinicians are often caught in a dilemma and other radiological methodologies are needed. The retrospective study was carried out to determine whether detailed intramedullary examination accomplished by adjusting the window-level and -width on uninformative T1-weighted images would facilitate the differential diagnosis.

Materials and Methods

Background of patients

Eight patients (3 males and 5 females) 11 to 63 years of age (mean, 41 years) with a histologically documented intramedullary spinal cord tumor were selected for the study. The selection criteria were that the lesion was hyperintense on T2-weighted images, and enhanced with administration of gadolinium,

but isointense to the normal spinal cord on T1-weighted images and poorly demarcated. In all patients definite diagnosis was difficult before operation. Histologically, the lesions included 3 astrocytomas, 1 neuroglioma, 1 neurilemoma, 1 ganglioma, 1 germinoma, and 1 angioma.

Seven patients (3 males and 4 females) 15 to 52 years of age (mean, 39 years) with MS who had acute signs and symptoms of transverse myelopathy without brain or optic nerve lesions were also selected for the study. Making a definite diagnosis in these patients was initially difficult, but all patients showed clinical improvement with the corticosteroid pulse therapy, and during their clinical course the clinical diagnosis of MS were determined by neurologists at our hospital.

The radiological investigation in this study was performed and interpreted without any knowledge of patients' diagnoses.

Investigation of the findings on magnetic resonance imaging

Conventional MR imaging

MR imaging performed at the first instance of transverse myelopathy was selected in the patients with spinal cord tumor or MS. MR imaging was performed with a 1.5-T instrument (Vision, Siemens) with the use of a spine coil. All patients underwent T1-weighted imaging with and without administration of gadolinium, and T2-weighted imaging. T1-weighted imaging included the following sequences of conventional spin-echo (400-600/12-22 [repetition time msec/echo time msec]). T2-weighted imaging included conventional spin-echo (3000-4000 / 90 or 100). Gadolinium-enhanced imaging included conventional spin-echo (400-600/12-22) with fat suppression. These images were filmed in a standard window by well-trained technologists.

Further investigation of T1-weighted images

T1-weighted images without gadolinium enhancement were used in this study. Data from the T1-weighted images stored previously were transferred to a Siemens Workstation, and adjusted manually to the window-level and -width, focusing on the

area of spinal cord lesion which was detected on T2-weighted imaging and gadolinium enhanced imaging. The window-level and -width were gradually changed until the signal of vertebrae was very bright and the signal of disc was very dark. After these adjustments were made, no other structures than the spinal cord could not be observed (Fig. 2 & 4). Readjusted MR images were referred to targeted T1-weighted MR imaging in this study. If the margins of the lesion within the isointense area on conventional T1-weighted images were apparent on the monitor in targeted T1-weighted MR imaging, the finding was positive. If there was no new information, the finding was negative.

Statistical analysis

In all patients the findings were determined to be positive or negative on targeted T1-weighted MR imaging. Sensitivity and specificity were calculated with regard to positive findings in patients with spinal cord tumor. Statistical analysis was performed with commercial software (SPSS for Windows, Inc., London UK). The association between positive findings on targeted T1-weighted MR imaging and the presence of spinal cord tumor was analyzed with the chi-square test.

Results

Findings on conventional MR imaging.

Hyperintensity was noted in the spinal cord on T2-weighted images in all patients. The length of hyperintense area was within two vertebral body segments in all patients with MS or spinal cord tumors. These were all isolated lesions. No cavity formation was seen in any patients. On T1-weighted images only isointensity and spinal cord swelling were demonstrated; no further information was added about the intramedullary changes in patients when they were filmed with the window-level of a standard setting (conventional MR imaging). Finally, on conventional MR imaging, no definite findings were obtained to differentiate between spinal cord tumor and MS.

Findings of targeted T1-weighted MR imaging

On targeted T1-weighted MR imaging,

positive findings were obtained in 6 of the 8 patients with intramedullary spinal tumors. In these 6 patients, distinct margins with heterogeneous internal signal intensity were clearly demonstrated by changing the window -level and -width. On the other hand, no lesion margin was detected (negative finding) in any patient with MS (Table 1). With regards to the appearance of lesion margins

(positive findings) in the patients with spinal cord tumor, targeted contrast MR imaging had a sensitivity of 100% and a specificity of 78%. Signal intensity on T1-weighted images differed significantly between intramedullary spinal tumors and multiple sclerosis ($P=0.007$, contingency table analysis, chi-square test).

Table 1. Results of findings on targeted T1-weighted image

	intramedullary spinal tumor (n=8)	multiple sclerosis (n=7)
positive	6	0
negative	2	7

(sensitivity :100% specificity :78% $P=0.007$)

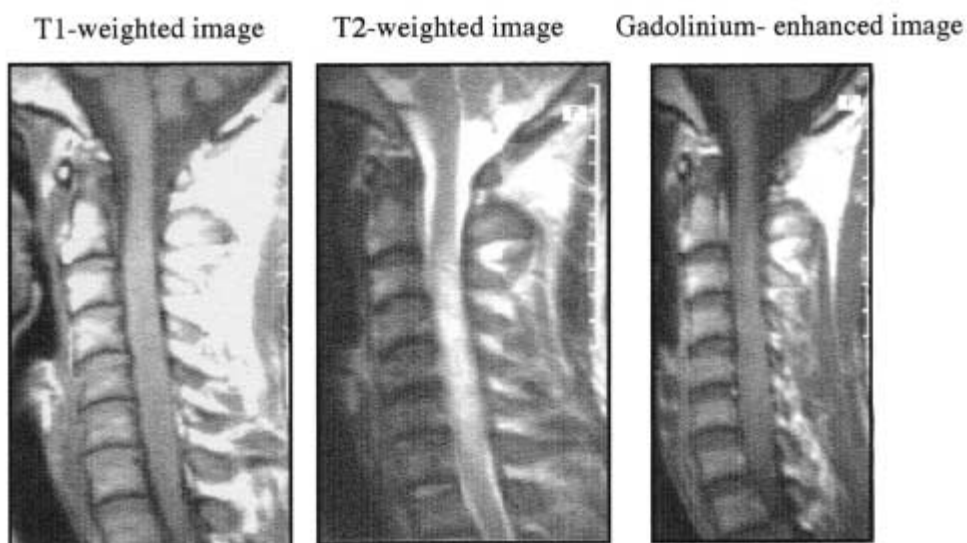


Fig. 1 Case 1.

Conventional MR images obtained a 37-year-old man with astrocytoma. The lesion of interest is isointense on T1-weighted imaging. It provides no useful information.

Case 1

The patient was a 37-year-old man with astrocytoma. On conventional MR imaging the patient had a lesion that was isointense on T1-weighted images and hyperintense on T2-weighted images. With administration of gadolinium the lesion was slightly enhanced,

but the tumor margin was poorly demarcated (Fig. 1). Images obtained by conventional MR imaging were thus uninformative. However, on targeted T1-weighted MR imaging, the tumor showed higher signal intensity than normal spinal cord, and the tumor margin was well demarcated. A cystic structure was seen inside the lesion (Fig. 2).

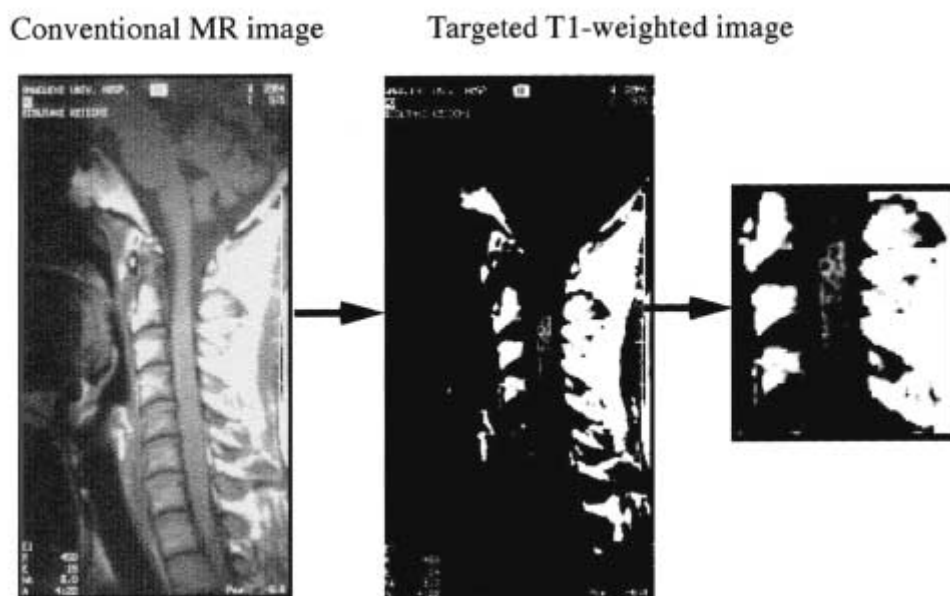


Fig. 2 Case 1.

The tumor is isointense on conventional MR imaging, but is more hyperintense than normal spinal cord on targeted T1-weighted image, and the tumor margin is well demarcated.

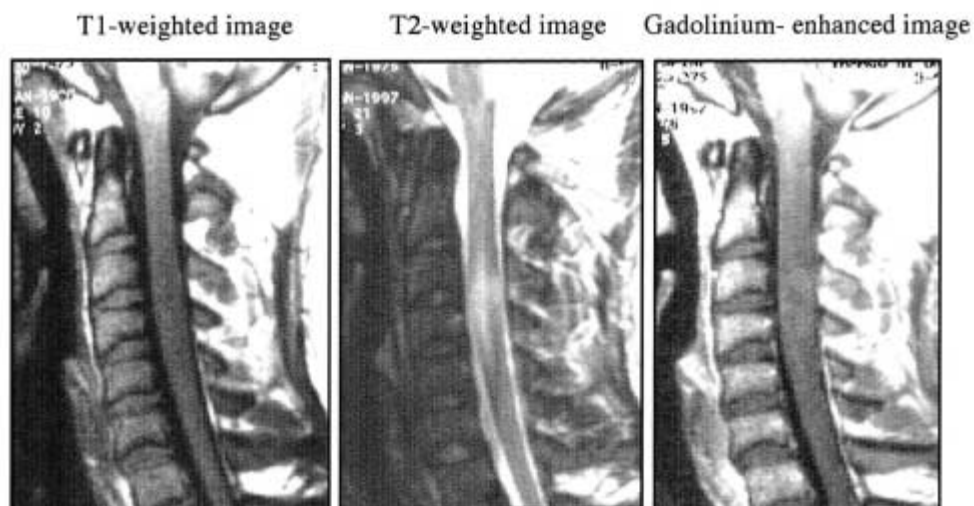


Fig. 3 Case 2.

Conventional MR images obtained in a 22-year-old man with multiple sclerosis. The lesion of interest is isointense on T1-weighted imaging. It provides no useful information.

Case 2

The patient was a 22-year-old man with multiple sclerosis. The lesion was slightly enhanced with administration of gadolinium, but the lesion margin was poorly demarcated.

Information for differential diagnosis was limited (Fig. 3). On targeted T1-weighted MR imaging, there was no change in the isointense areas compared with conventional MR imaging, and no additional features were observed (Fig. 4).

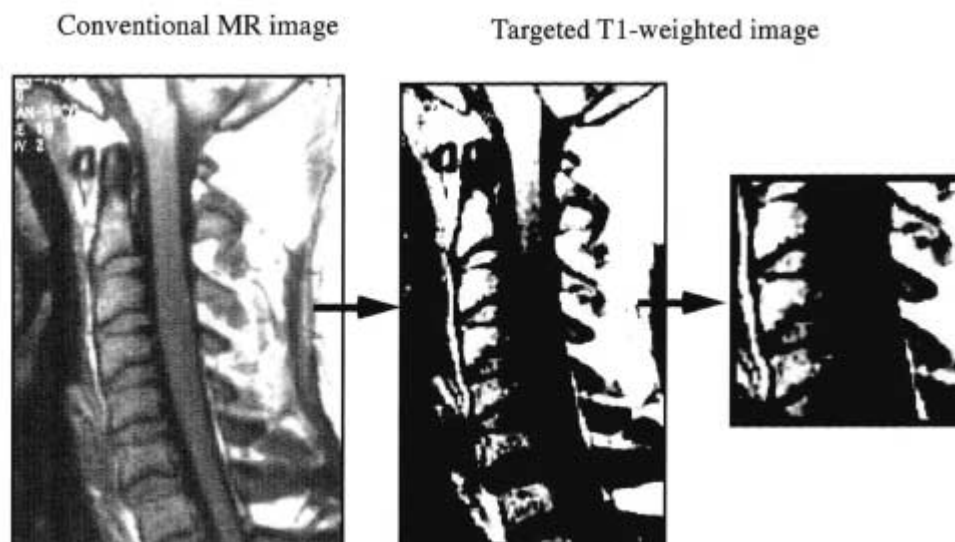


Fig. 4 Case 2.

T1-weighted images obtained by targeted T1-weighted MRI.

New information was not added even after altering the window level.

Discussion

Since the development of MR imaging, it has been easy to detect intramedullary spinal cord diseases. However, it is often difficult to differentiate clinically between intramedullary spinal cord tumor and MS in patients with acute transverse myelopathy. Because 15% to 20% of all cases of MS occur in the spinal cord, the clinical features and radiological findings may mimic those of spinal cord tumors. Karn et al.¹⁾ and Scotti et al.²⁾ reported that most intramedullary spinal cord tumors were hypointense to isointense on T1-weighted images, hyperintense on T2-weighted images, and enhanced with administration of gadolinium. The signal intensity may vary considerably depending on the tissue type and time of examination. The differential diagnosis is often possible on the basis of characteristics on MR imaging. Epitheliomas have border-like cavity, Astrocytomas show infiltrate growth and their tumor margins are poorly demarcated. Hemangioblastomas are

characterized by a flow void associated with dilated tumor vessels. On the other hand, Tartaglino et al.³⁾ found that plaques associated with MS of the spinal cord are hypointense to isointense on T1-weighted images, hyperintense on T2-weighted images, and enhanced with administration of gadolinium. Most plaques are oval, relatively well demarcated, and located posterolaterally and within an area of less than two vertebral segments in length. Considering these findings, the MR imaging characteristics of intramedullary tumors are similar to those of some types of MS with active enhanced lesions, so that diagnostic difficulties are often encountered. Mark et al.⁴⁾ reported that demyelinating changes were observed in 9 of 212 (4%) patients who underwent surgery because of suspected spinal cord tumor diagnosed on the basis of MR imaging findings. Several authors have proposed that it is often difficult to differentiate between intramedullary spinal cord tumor and MS in patients with acute transverse myelopathy.^{5),6),7)}

Although T2-weighted images are best suited for the detection of spinal lesions, hyperintense areas often show nonspecific findings in spinal cord tumors, MS and other conditions. T1-weighted images are generally better than T2-weighted images for morphologic evaluation. However, conventional T1-weighted images of many intramedullary spinal cord tumors show the same signal intensity as the normal spinal cord and are thus uninformative. Computed tomography (CT) and radiography generally can record two types of images on films, bone and soft tissue, depending on the target tissue. The window -level and -width can be focused on the desired tissue and the contrast adjusted. In this study special attention was paid to this window setting. Because MR imaging expresses relative values whereas CT displays absolute CT values, on one sequence, only a window-level and -width providing a balanced view of structures such as vertebral bodies, intervertebral discs, ligaments, and the spinal cord is generally used. Under this condition, the spinal cord on T1-weighted images is often isointense and hence the images are uninformative. Therefore it is difficult to evaluate intramedullary spinal lesions by using only standard film MR imaging. To solve this problem, the data from previously stored T1-weighted images were transferred to a Siemens Workstation and the images were adjusted to the window-level and -width to demonstrate the border, internal structure, and other characteristics of intramedullary lesions. As a result, 6 of 8 intramedullary tumors were slightly better demarcated and showed a heterogeneous internal structure, whereas new information was not obtained in any patients with multiple sclerosis. In acute multiple sclerosis, although the medullary sheath degenerates, the axial filament is preserved. Therefore the histological changes could not be detected on T1-weighted images. However, in patients with intramedullary tumors, T1-weighted images showed changes such as capsule formation, internal bleeding, and mucus production. In particular, hyperintense areas on T1-weighted images such as presented in case 1 corresponded to a pathological feature. These results should

be expected. This technique may be a pitfall for clinician in the diagnosis on MR imaging. In deciding on a therapeutic strategy, the most important stage is the onset of acute transverse myelopathy. Targeted contrast MR imaging is particularly useful at this time because in most cases MS does not yet show histological change of wide necrosis as hypointensity on T1-weighted images.

Recently, new techniques such as MR spectroscopy, magnetization transfer, and diffusion imaging have been used for the diagnosis.^{8),9),10)} However, whereas these techniques require special MR imaging equipment, targeted contrast MR imaging is easily performed and can even be used for retrospective evaluation if the data were stored in a computer.

Conclusions.

Intramedullary spinal cord tumors and MS can be differentiated on T1-weighted imaging by changing and adjusting the window-level and -width focused on the intramedullary region of interest. This technique provides us additional information on the spinal cord, which cannot be obtained from conventional MR imaging.

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