Clin Neuroradiol (2019) 29:639–644
https://doi.org/10.1007/s00062-018-0721-1

ORIGINAL ARTICLE

Cervical MRI Rating Scale: Innovative Approach to Differentiate between Demyelinating and Disc Lesions

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Received: 6 April 2018 / Accepted: 3 August 2018 / Published online: 23 August 2018

Abstract

Purpose The difficult differentiation between multiple sclerosis (MS) lesions and cervical spondylotic myelopathy (CSM) in the cervical spine is well known. The magnetic resonance imaging (MRI) appearance of both lesions is similar, and clinical parameters are usually used for diagnosis. The objective was to establish a reliable radiologic paradigm for diagnosis of demyelinating lesions in the cervical spine.

Methods The MRI studies of 33 patients with MS (42 lesions) and 55 patients with CSM (60 lesions) were obtained. Lesions were evaluated for vertebral level, lesion location and size in the sagittal and axial planes, cord thickness, well-defined or ill-defined borders, presence of edema and enhancement with gadolinium. Significant differences were used to create a paradigm, which was used for the evaluation of a different group of 32 MRIs with 42 concomitant MS and CSM lesions.

Results Significant differences were seen in the level, location within the cord in both planes, lesion size, cord thickness and lesion border. The MS lesions were well-defined lesions found in C1–3, posterior in the sagittal plane, central in the axial plane, with a normal or increased cord thickness. Good agreement was seen in the validation stage.

Conclusion The new CSM-MS lesion score allows accurate diagnosis of demyelinating lesions in the cervical spine vs. CSM lesions.

Keywords Multiple sclerosis · Chronic spondylotic myelopathy · MRI · Differential diagnosis · Demyelinating lesions

Introduction

Multiple sclerosis (MS) is an autoimmune central nervous system disease affecting 2.5 million people worldwide. The typical lesions in MS affect the brain and spinal cord and cause demyelination and axonal loss over time [1–3]. The cervical region is the most frequently involved part of the spinal cord in MS. The clinical presentation of cervical MS lesions includes spasticity, motor weakness, sensory impairment, spastic gait and/or bowel and bladder control difficulties. Similar symptoms are caused by degenerative changes in the cervical spine with or without compression that become frequent with increasing age, leading to chronic spondylotic myelopathy (CSM) [4–11]. The incidence of cervical disc disease in MS patients is similar to the general population, with increasing incidence over the age of 50 years, thus causing a significant difficulty in differential diagnosis [4, 5]. The correct diagnosis will influence the treatment, either with high-dose steroids in a new MS lesion and a change in the medicinal immunomodulatory regimen or conservative rehabilitation approach and/or surgical intervention in CSM.

Magnetic resonance imaging (MRI) examination of the cervical spine is used to identify both MS lesions and CSM, and both have similar MRI findings of hyperintense T2 signal and a low intensity T1 signal [1–3, 10, 11]. Currently, no radiological guidelines for differential diagnosis of these lesions are available [10, 11] and the diagnosis is based on clinical findings such as neck pain, radicular pain and absent tendon reflexes that mainly represent radicular signs of disc herniation and not myelopathy published in 1957 by Brain

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and Wilkinson [12] and has not changed significantly since [4].

The aim of the study was to establish a reliable radiologic paradigm to separate the cervical MS lesion and CSM. The developed paradigm was targeted to be simple, easily memorable, summarized in a simple chart and applicable by clinicians and radiologists without the use of special equipment.

Methods

Study Design

First stage: open, retrospective for development of the radiologic paradigm. Second stage: validation analysis for the developed paradigm. The Sheba Medical Canter IRB committee approved the study.

Cervical MRI examinations of MS and CSM patients performed at the Sheba MS Center and the Orthopedic Division were analyzed. Patients with clear-cut diagnosis of either MS or CSM were specifically selected to build the diagnostic radiologic paradigm. Cervical MRI scans were performed using 1.5 or 3 T MRI GE (General Electric, Boomtown, CA, USA) scanners. The MRI prerequisites for inclusion were: T1 and T2 sequences in the sagittal and axial planes and T1 scans after administration of gadolinium, extending from the foramen magnum to the lower border of C7. Only studies extending from the superior aspect of the C1 vertebral body to the inferior aspect of C7 were analyzed. The slice thickness was 3 mm in all the scans.

Each cervical lesion was evaluated for the following characteristics:

1. Cervical spine level
2. Lesion location in the sagittal and axial planes
3. Lesion size in both planes
4. Cord thickness compared with one level above and one below the lesion
5. Lesion border definition: well-defined or not
6. Presence/absence of edema
7. Presence/absence of enhancement by gadolinium

Each of the 7 variables was scored as 0 suggestive of CSM, and 1 or 2 suggesting an MS lesion. Variables 1, 3, 4, 6, and 7 received a score of 0 or 1, and variables 2 and 5 had a maximum score of 2, making a total score of up to 9. Variables that did not differentiate significantly between MS and CSM were withdrawn from the final score, leading to a final score range between 0 and 7. A logistic regression model estimating the relative contribution of each of the 5 variables to the paradigm was used to define grades for CSM or MS lesion.

Validation

Validation of the paradigm was performed on cervical MRI data obtained from an additional independent group of patients with concomitant MS and CSM using the new grading system. The MRIs were interpreted by an experienced neuroradiologist (CH) and an experienced spine orthopedic surgeon (AF) independently, using the CSM-MS lesion score, without knowledge of any clinical details, and each one graded the lesions and diagnosed them as related to CSM or to MS. The patient charts were reviewed 1 year following the validation and a final diagnosis whether the lesion was due to MS or CSM was established, based on clinical variables and response to treatment.

Statistical Analysis

Demographic and disease-related variables were analyzed using SAS software (Cary, NC, USA). Patient characteristics were summarized using descriptive statistics appropriate to variable type. The prevalence of each radiologic risk factor was estimated for MS and CSM patients. In the primary analysis, MS patients were compared with CSM patients using χ^2-test or Fisher's exact test for categorical data and 2-tailed t-test for normally distributed continuous variables.

In the multivariate analysis a logistic regression model was developed to estimate the relative contribution of each variable to the paradigm.

Results

Patients

MS Group A total of 47 cervical spinal cord lesions were identified in a group of 33 MS patients, 20 females, 13 males, age 46.3 ± 4.7 years (mean ± SE), disease duration 5.2 ± 1.9 years, mean neurologic disability as evaluated by the Expanded Disability Status Scale (EDSS) score 3.1 ± 1.2.

CSM Group A total of 60 lesions were identified in a group of 55 CSM patients, 10 females, 45 males, age 57.2 ± 3.9 (mean ± SE) years, disease duration 8.5 ± 2.4 years.

Spinal Cord Paradigm Variables

1. Level: the level of the lesion in the cervical spine was significantly different between the MS and CSM patients (Table 1). The MS lesions were equally distributed along the spinal cord while CSM had an anatomic predilection

Table 1 Involved levels in the cervical spine

Level	MS *n* (%)	CSM *n* (%)
C1	7 (14.9)	0 (0)
C2	8 (17.0)	1 (1.7)
C3	7 (14.9)	13 (21.7)
C4	9 (19.1)	18 (30)
C5	7 (14.9)	18 (30)
C6	5 (10.6)	9 (15)
C7	3 (6.4)	1 (1.7)
Multiple levels	1 (2.1)	0 (0)

The MS lesions were evenly distributed in all the levels while the CSM lesions were below C4

to the lower part of the cervical spine. Of the CSM lesions 76.7% were below the C3 level, while 46.8% of the MS lesions were between C1 and C4 levels ($p = 0.0011$).

2. Location: (a) axial plane, 72.3% of the MS lesions were central and 27.7% were lateral and no lesions involved the entire level of the cord. In the CSM group, 43.3% of the lesions were central, 48.3% were lateral and 8.3% involved the entire level of the cord ($p = 0.0047$). (b) Sagittal plane, 70.2% of the MS lesions were posterior, 21.3% were central, and 8.5% were anterior, while 18.3% of the CSM lesions were posterior, 65% were central, 3.3% were anterior, and 13.3% involved the entire level of the cord ($p < 0.001$; Table 2).
3. Size: the width of the MS lesions was significantly larger than those of the CSM lesions. The mean width of the MS lesions was 4.5 ± 0.2 mm and the width of the CSM lesions was 3.2 ± 0.4 mm ($p = 0.0135$). The mean length of the CSM lesions was 6.9 ± 1.3 mm and the mean length of the MS lesion was 9.1 ± 0.9 mm, but the difference was not statistically significant ($p = 0.1584$).
4. Thickness: in 80.9% of the MS lesions the cord thickness compared to one level above and one level below the lesion was normal, in 12.8% it was increased and in 6.4% it was decreased. In 95% of the CSM lesions the cord showed decreased thickness, in 3.3% increased thickness and in 1.7% normal thickness ($p < 0.001$; Table 3).
5. Lesion border definition: 87.2% of the MS lesions were well-defined and 12.8% lesions had ill-defined borders; 28.3% CSM lesions were well-defined and 71.7% were ill-defined ($p < 0.001$).
6. Edema: was seen in 10.6% of the MS lesions compared to 26.7% of the CSM lesions ($p = 0.0383$).
7. No difference in gadolinium enhancement of the lesions was seen between the two groups.

The significant parameters were the level of the lesion, the cord thickness, the location of the lesion in the cord in the sagittal and axial views and the lesion border definition. The variables of edema (6) and gadolinium enhancement (7) did not differentiate significantly between MS and CSM. They were withdrawn from the final score, leading to a final score range between 0 and 7; Logistic regression model estimating the relative contribution of each of the 5 variables to the paradigm demonstrated that a score of 0–3 is suggestive of CSM and a score of 4–7 suggestive of MS lesion. The CSM-MS score variables are shown in Table 4.

Validation

In the second stage of the study, an additional 32 MRIs were reviewed and 42 lesions were identified. The independent assessors used the CSM-MS lesion score on these lesions. An agreement between the assessors was reached in 36 (85.7%) lesions. The clinical validation performed 1 year following the MRI validation showed that in 37 lesions (88.1%) the CSM-MS lesion score result conformed with the clinical diagnosis.

Discussion

In the last three decades MRI has been used for the diagnosis of cervical myelopathy, whether it was caused by MS or CSM. The coincidence of lesions caused by CSM and MS is well known. Previous recommendations for the differential diagnosis between MS and CSM lesions used mainly clinical findings but no MRI criteria were suggested [4–6]. This study, to the best of our knowledge, is the first to assess MRI parameters in order to differentiate between a demyelinating MS-related lesion and a disc-related myelopathic lesion. The findings show that MS lesions were evenly distributed along the cervical spinal cord while CSM occurred most commonly in the lower segments of the cervical spine, and in 76% of the cases was seen below the C3 vertebra. These findings are not surprising as the inflammatory process in MS may involve any level of the spinal cord. On the other hand, disc degeneration is due to increased mechanical pressure in the lower cervical vertebrae [13, 14].

The location in the axial plane also showed a significant difference between MS and CSM lesions. Most of the MS lesions were central, while the CSM lesions were divided more evenly between central and lateral locations. The location in the sagittal plane showed the MS lesions to be more posterior, while the CSM lesions were mostly central. These findings are probably related to the pressure caused by the disc protrusion. Relating to the lesion size, MS lesions were wider and longer than the CSM lesions, but the difference was statistically significant only in the width.

The cord thickness was normal in the majority of the MS lesions and decreased in the majority of the CSM lesions, due to the mechanical pressure by the disc and osteophytes

Table 2 Lesion location in the cord in the axial and sagittal planes

	Axial plane location			Sagittal plane location			
	Central *n* (%)	Lateral *n* (%)	Full involvement *n* (%)	Central *n* (%)	Anterior *n* (%)	Posterior *n* (%)	Full involvement *n* (%)
MS	34 (72.3)	13 (23.7)	0 (0)	10 (21.3)	4 (8.5)	33 (70.2)	0 (0)
CSM	26 (43.3)	29 (48.3)	5 (8.3)	39 (65)	2 (3.3)	11 (18.3)	8 (13.3)

Table 3 The differences between the MS and CSM lesions

Parameter		MS	CSM	*P*-value
Level	C1–3	22 (46.8%)	14 (23.3%)	0.0011
	C4–7	25 (53.2%)	46 (76.7%)	
Lesion location (axial)	Central	34 (72.3%)	26 (43.3%)	0.0047
	Lateral	13 (23.7%)	29 (48.3%)	
	Full involvement	0 (0%)	5 (8.3%)	
Lesion location (sagittal)	Central	10 (21.3%)	39 (65%)	<0.0001
	Anterior	4 (8.5%)	2 (3.3%)	
	Posterior	33 (70.2%)	11 (18.3%)	
	Full involvement	0 (0%)	8 (13.3%)	
Mean lesion length (mean ± SE)		9.140 ± 0.914	6.944 ± 1.287	0.1584[a]
Mean lesion width (mean ± SE)		4.477 ± 0.215	3.196 ± 0.441	0.0135[a]
Cord thickness	Normal	38 (80.8%)	1 (1.7%)	<0.0001
	Increased	6 (12.8%)	3 (3.3%)	
	Decreased	3 (6.4%)	57 (95%)	
Lesion border	Well-defined	41 (87.2%)	17 (28.3%)	<0.0001
	Ill-defined	6 (12.8%)	43 (71/7%)	
Edema	Present	5 (10.6%)	16 (26.7%)	0.0383
	Absent	42 (89.4%)	44 (73.3%)	
Gadolinium enhancement	Present	7 (14.9%)	4 (6.7%)	NS
	Absent	40 (85.1%)	56 (93.3%)	

Significant differences were found in the level of the lesion, lesion location in the axial and sagittal planes, lesion width, spinal cord width at the level of the lesion, lesion border delineation and edema

[a]T-test

NS not significant

Table 4 The scoring system

Variables	Point score		
	0	1	2
Level	C4–7	C1–3	–
Cord thickness	Decreased	Increased	Normal
Location in the sagittal view	Anterior/central/combined	Posterior	–
Location in the axial view	Lateral	Central	–
Lesion delineation	Ill-defined	–	Well-defined

The scoring system developed based on the significant factors identified in a logistic regression. A score 0–3 points suggests CSM; a score of 4–7 points suggests the diagnosis of MS

found in CSM [13, 14]. There was increased thickness of the cord in 12.8% of the MS lesions, and this finding was attributed to the inflammatory process and edema associated with it. Most of the MS lesions were well-defined, while the majority of the CSM lesions demonstrated an ill-defined lesion border. Edema was more common in the CSM group with a statistically significant difference, but the majority of the patients in both groups showed no edema. There was no difference between the groups in gadolinium enhancement.

In conclusion, MS lesions are seen more frequently in the higher cervical levels (C1–3), with a normal or wider than normal cord thickness, central in the frontal plane and posterior in the sagittal plane, and usually well-defined. In contrast, CSM lesions were most commonly found in the lower levels of the cervical spine, with decreased cord thickness, localized centrally in the frontal plane and anterior or central in the sagittal plane, and are less well-defined. Typical MRI findings of MS lesions are shown in Fig. 1 and typical CSM lesions are shown in Fig. 2.

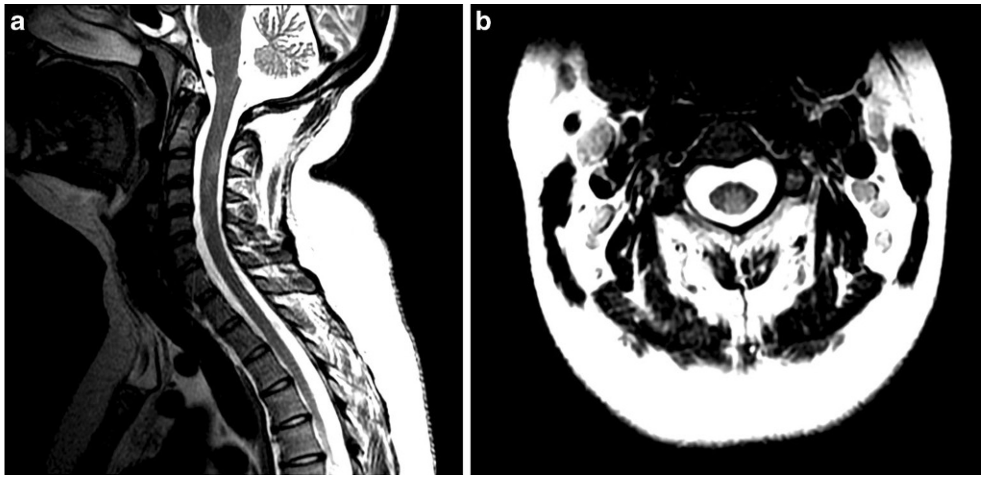

Fig. 1 **a** An MS patient with a typical demyelinating lesion at the level of C3. Sagittal T2 sequence demonstrating a well-demarcated hyperintense lesion at the posterior part of the cord. **b** An MS patient with a typical demyelinating lesion at the level of C3. Axial T2 sequence at the level of C3 demonstrating the same central posterior lesion

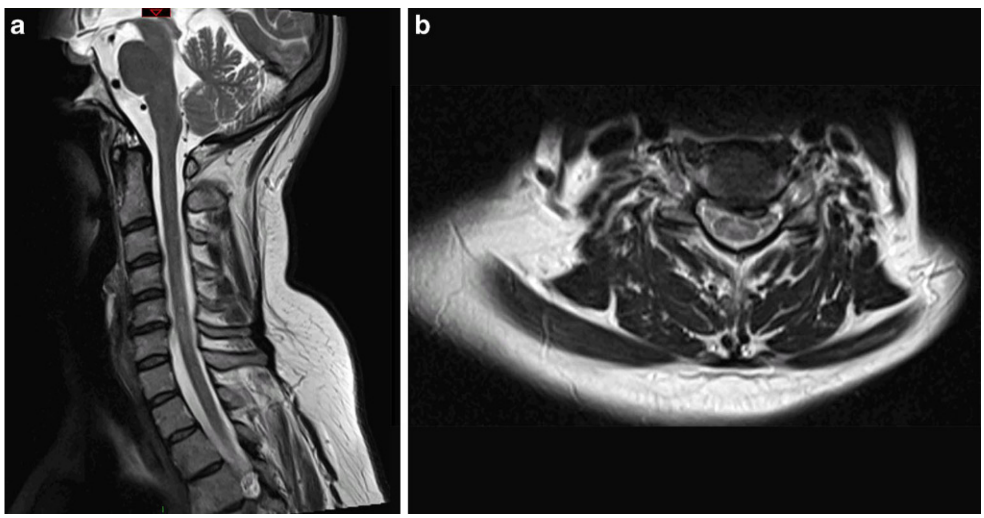

Fig. 2 **a** A patient with CSM and spinal stenosis. A sagittal T2 sequence demonstrating narrow stenosis due to disc bulges at the level of the C5–C6 disc space. **b** An axial T2 sequence at the same level showing a central disc bulge, compressing the spinal cord

These findings were developed into a simple grading system, allowing easy classification of the lesion. Only the most significant factors were included in the algorithm, trying to keep it simple, and thus excluded the lesion size and the presence of edema. Application of the grading system to a new group of patients with concurrent MS and CSM, resulted in a good interrater agreement achieved between the physicians evaluating the MRIs. The parameters identified are the involved level in the spinal cord, cord thickness, the location in the cord both in the sagittal and the axial views and whether the lesion is well-defined. The parameters are easily memorized and the table can be posted in clinics for physician use. The MRI diagnosis was consistent with the clinical diagnosis of the patients in the majority of the reviewed lesions, supporting the view that this is a valuable tool for the clinician dealing with patients with MS.

Conclusion

The new CSM-MS lesion score for differential diagnosis between MS and CSM lesions is reliable, simple and easy to use by clinicians in any setting.

Acknowledgements The authors thank Ms. Yael Nissan for figure preparation.

Conflict of interest U. Givon, C. Hoffman, A. Friedlander and A. Achiron declare that they have no competing interests.

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