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# MRI of spinal cord in MS

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**Over the last 10–15 years, magnetic resonance imaging techniques have had a major impact in understanding and managing multiple sclerosis. The present review briefly summarises the current usefulness of spinal cord MRI in MS disease, examining the frequency, distribution and main characteristics of spine MS plaques; the differential diagnosis with other spinal cord disease was also described. Finally we considered how newer imaging sequences when added to semi-automated quantitative methods, may give us a putative tool to reliably quantify subtle changes which develop on the spinal cord of MS patients over time.** *Journal of NeuroVirology* (2000) **6,** S130–S133.

**Keywords:** multiple sclerosis; magnetic resonance imaging; spinal cord

## Introduction

Magnetic Resonance Imaging (MRI) is an established tool in the diagnosis of Multiple Sclerosis (MS) and its serial application is providing profound new insights in understanding pathological mechanisms which lead patients to progressive disability (Grossmann *et al*, 1998; Miller *et al*, 1998).

Involvement of spinal cord is a common finding in MS as many of the clinical effects, particularly those responsible for the progression of disability, are associated with spinal cord damage. Several studies have recently focused on improving spinal cord imaging techniques, and to analyse correlations between spinal MRI findings and progressive disability over time (Tartaglino *et al*, 1995; Thorpe *et al*, 1996; Stevenson *et al*, 1998).

MS plaques may affect spinal cord in isolation ($\cong$20%) or more commonly, both the brain and spinal cord (Thorpe *et al*, 1996). Cervical area is more frequently involved than the thoracic area (Uldry *et al*, 1993; Kidd *et al*, 1993), though this may be related to different image quality and to the failure of detecting small lesions at the level of thoracic cord. Lesions tend not to affect the entire cord, showing a peripheral location and involving either grey and white matter (Tartaglino *et al*, 1995). The length of lesions may range from 3 to 60 mm, albeit a diffuse and confluent abnormality spanning along the entire cervical spine is often observed (Figure 1). Spinal cord signal alterations tend to disappear over the time when sectorial cord atrophy persists (Figure 2). MRI of spinal cord is important in the context of patients with clinical signs and symptoms referring to MS. Diagnostic sensitivity may arise when documenting lesions in the cord of patients in whom brain MRI findings are normal (Kidd *et al*, 1996). Spinal cord MRI permits, moreover, the exclusion of neurological symptoms which were mistakenly related to MS such as intrinsic or extrinsic tumour. Thorpe *et al* (1996) reported that using current MRI technology the addition of spinal cord MRI may increase the sensitivity in diagnosing MS nearly to 100%.

*Differential diagnosis*

Many other lesions may show a similar pattern to that of MS plaques. The broad differential diagnosis of multiple high signal abnormalities in the spine include: tumour (Maurice *et al*, 1994; Bravermann *et al*, 1997); vascular disease such as dural arteriovenous malformation, which may cause venous hypertension with subsequent venous infarction; inflammatory disorders: Systemic Lupus erythematosus (SLE), Primary Sjogren's syndrome, Polyarteritis nodosa (PAN), Behcet's disease; infectious disease: acute disseminated encephalomyelitis (ADEM) (Figure 3); neuroborelliosis (Lyme disease) and HIV; sarcoidois (Fieschi *et al*, 1995; Gasperini *et al*, 1997). Another frequent problem is determined by older adults (over 60

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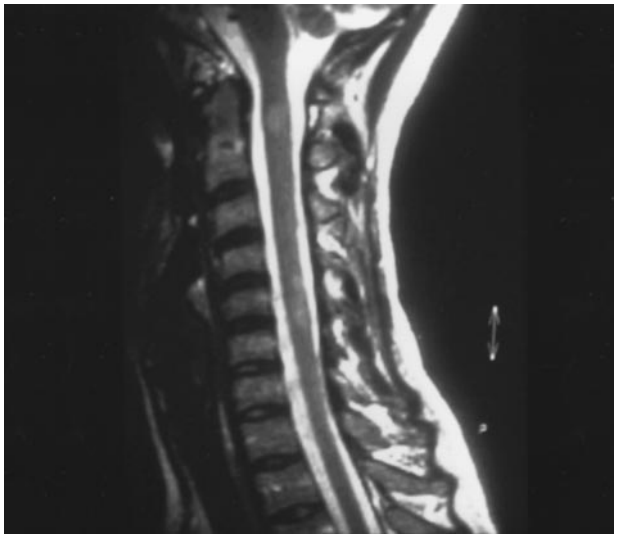

**Figure 1** T2 weighted sagittal images. A diffuse signal alterations are evident within the cervical spinal involving also the medulla.

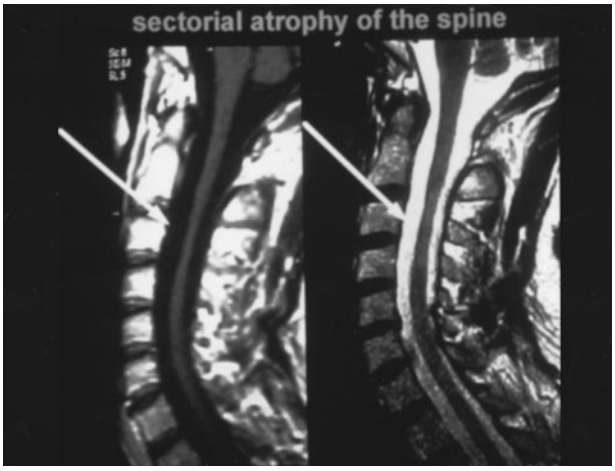


**Figure 2** T1 and T2 weighted sagittal images. A sectorial cord atrophy is well evident at the level of the cervical spine as a consequence of a previous lesion.

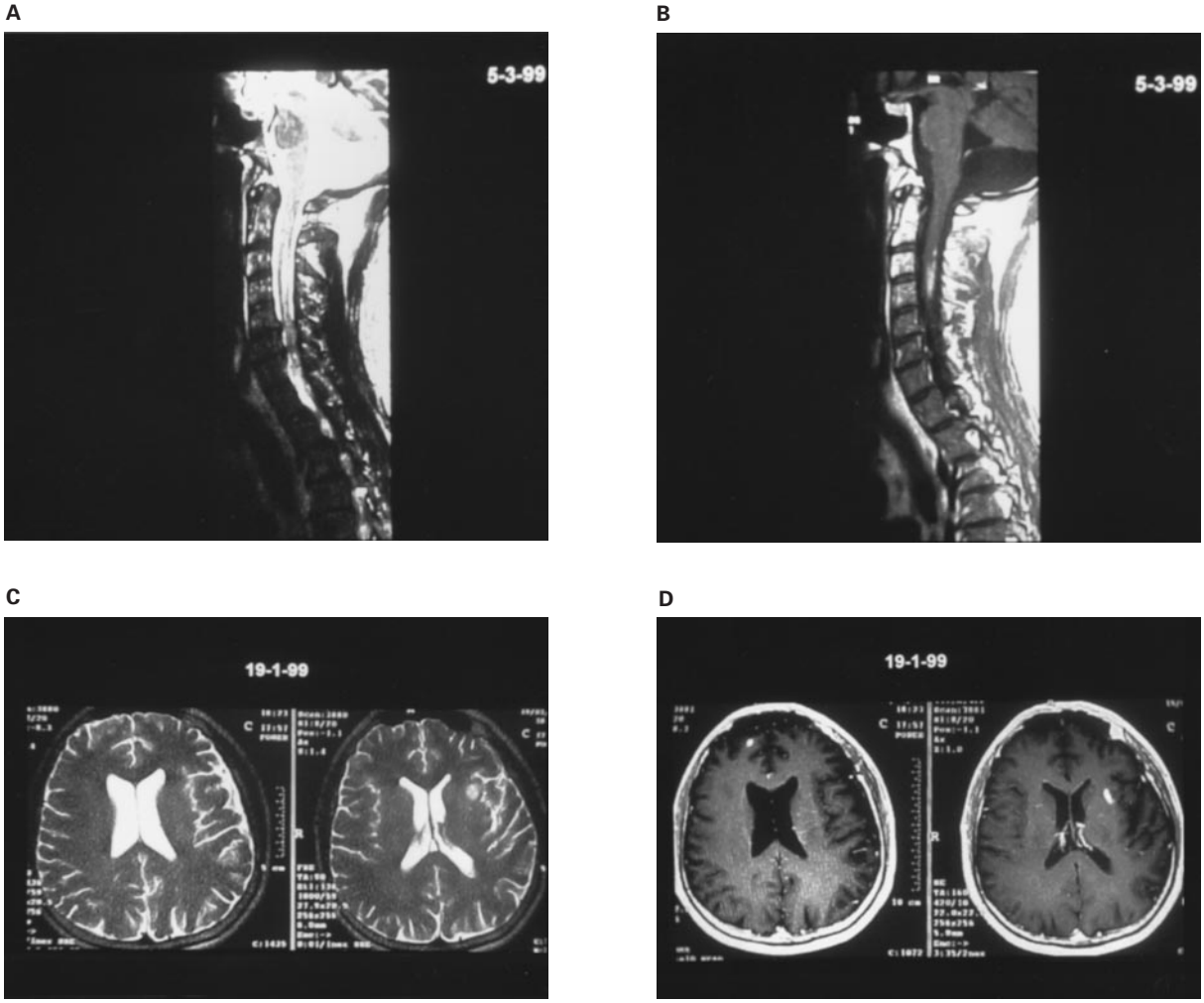


**Figure 3** Acute Disseminated Encephalo Mielopathy (ADEM). A wide lesion with homogeneous contrast enhancement is present at the C3–C4 spine level (**A,B**). At the same time two other lesions with homogeneous contrast enhancement are evident in the brain (**C,D**); no other abnormalities are present and every lesion has been revealed simultaneously. These findings and clinical-radiological evolution confirmed the diagnosis of ADEM.

years of age) who are unaware that they have MS. The progressive cord involvement needs to be differentiated from cervical spondylosis, albeit an association between cervical spondylosis and MS has been reported (Burgerman *et al*, 1992) (Figure 4); in this context, the presence of brain abnormalities may aid in the diagnosis of MS.

*Spinal cord MRI sequences*

Several studies have reported controversial results concerning the best MRI pulse sequence for evaluating spinal cord disease. For detecting MS plaques, cardiac triggered dual-echo acquisitions on a sagittal plane are considered superior to magnetisation transfer-prepared gradient-echo (Lycklama a Nijeholt *et al*, 1996). Compared to conventional spin-echo, fast spin-echo (FSE) appeared similar in depicting MS plaques with a real improvement in time taken (Figure 5). Fast-fluid attenuated inversion recovery (fast-FLAIR) sequences did not detect as many lesions in the spinal cord compared with supratentorial brain lesions and when correlated with FSE a lesser load of lesions were detected in the spinal cord (Filippi *et al*, 1996).

*Spinal cord atrophy in MS*

Previous studies reported no significant correlation between the number and extention of T2 abnormalities in spinal cord with disability in either cross-sectional and serial evaluation (Kidd *et al*, 1993, 1996). The presence of spinal cord atrophy, which may be focal at the site of the lesions or involve forespine as a consequence of axon degeneration, has also been observed by several authors, who underlined the putative role of measurement of cord atrophy as a marker of axonal loss and have reported significant close correlation with disability (Losseff *et al*, 1996; Stevenson *et al*, 1998; Paolillo *et al*, 1999).

Kidd *et al* (1993) reported the first quantitative study of the spinal cord acquired on axial section at four vertebral levels (C5, T2, T7 and T11). The means cord areas of the MS patients were significantly smaller than that of control subjects, and those patients with atrophy had higher disability evaluated by Expanded Disability Status Scale (EDSS) (Kurtzke, 1983). Further studies were performed in a serial fashion, measuring across

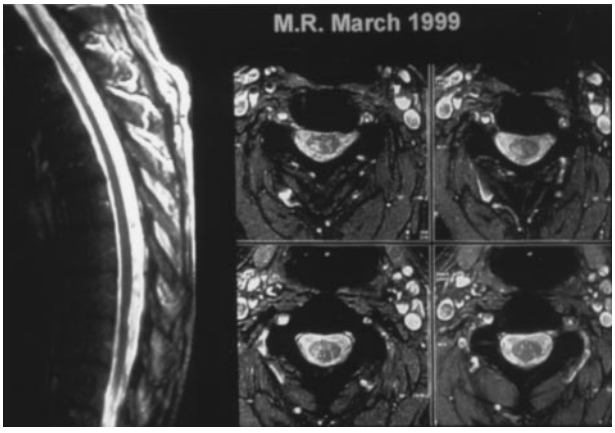


**Figure 5** T2 spinal cord images on sagittal planes. The whole spine is well evident using fast spin-echo sequences and wide field of view.

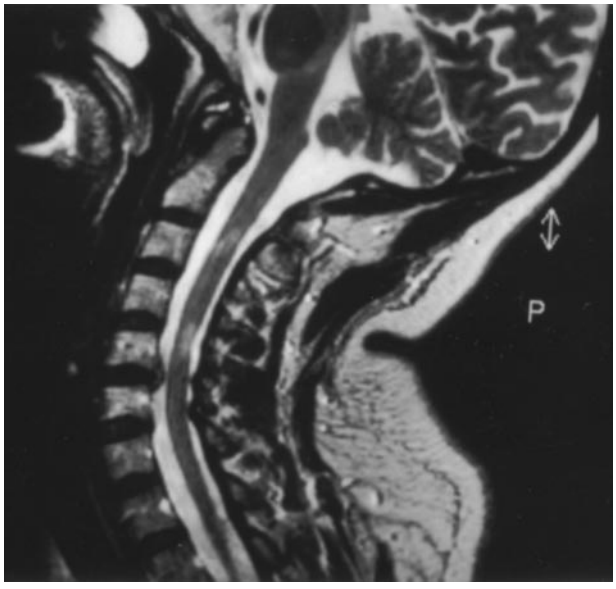


**Figure 4** T2 weighted image on sagittal plane showing both MS alterations of the spine and a disk herniation.

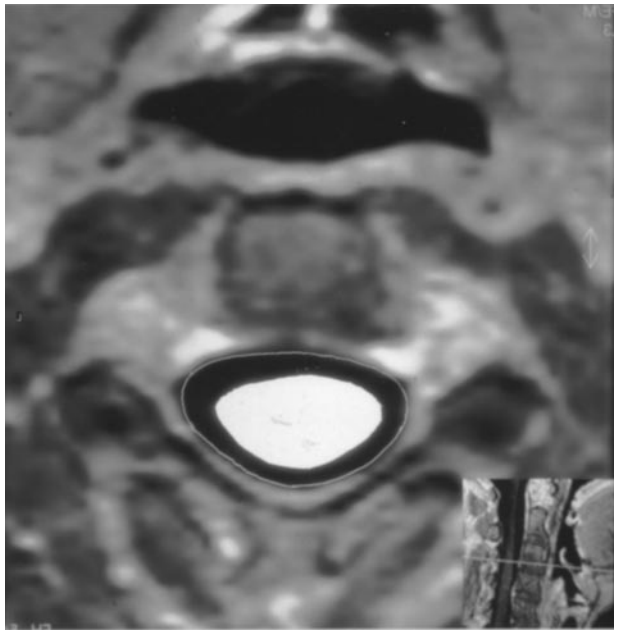

**Figure 6** Reformatted axial spinal image at C2–C3 level are obtained to evaluate the cord area.

sectional area at the C5 level (Filippi *et al*, 1996; Thorpe *et al*, 1996); these reported contrasting data with regards to correlations between spinal cord atrophy and clinical worsening. The intrarater reliability of the measurement technique was 2%, but the scan re-scan variability was near to 6% (Kidd *et al*, 1996). This poor reliability has been explained by the use of two-dimensional imaging with gradient echo sequences and with the use of the C5 level. At this level, in fact, flow turbulence and signal void are frequent, determining a decrease in small lesions depiction and the use of manual outlining technique in measuring cross-sectional spinal area. These problems were recently resolved by examining the cord area at C2–C3 level using a volumetric-acquired inversion-prepared fast spoiled gradient-echo (Losseff *et al*, 1996). This technique evaluates the mean values of cord and CSF signal intensity after which an automated cord limit can be determined by taking the mean of these measurements (Figure 6). Using this method, Losseff *et al* (1996) found a high reliability with a scan re-scan of 0.8% and a high graded correlation between cord cross-sectional area and disability. The same technique was also applied over a 1-year period, to assess whether it was possible to measure changes in cord cross-sectional area serially (Stevenson *et al*, 1998; Paolillo *et al*, 1999). These studies demonstrated a comparable scan re-scan reliability with Losseff's data, highlighting the possibility to measure changes in a cross-sectional area over time. Both these studies, moreover, confirmed that spinal cord atrophy was strongly correlated with increased disability.

The longitudinal measurements of spinal cord atrophy may therefore give us an important contribution in understanding pathological mechanisms which are responsible for a disability progression.

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