Biplanar Spinal Cord MRI in MS - Depiction of Cord Pathology and Improvement of Clinical Correlations

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Introduction: The spinal cord (SC) is frequently and often extensivley involved in MS and an area of particular interest as its functional role is so frequently compromised in MS. So far association between these MR findings and clinical symptoms is weak (1-4). However the identification of pathology is technically and anatomically demanding and false positive and false negative results are common. We employed biplanar (sagittal and axial) T2-and Proton Density(PD)-weighted MRI of the whole cord in order to visualize the known pathological features: focal lesions, diffuse hyperintense abnormality, focal and generalised atrophy. We furthermore tried to integrate pathological findings in a meaningful way in order to categorize pathological findings and compare them to clinical functional scores.

Methods: 202 MS patients with a broad spectrum of clinical characteristics (140 women, 62 men, 24-74 years old, EDSS 0-7.0) with different MS subtypes were included. Examinations were performed on a 1.5T MRI system, MAGNETOM Avanto (Siemens Medical Solutions) using multi-array-coils and parallel imaging techniques (Siemens acronym: TIM technology). The standardized spinal cord MRI included sagittal (2 overlapping FOVs of 350x350 mm^2, voxel size: 1.0x0.8x3 mm^3) and transverse (voxel size 1.1x0.5x6 mm^3) Proton Density and T2-weighted turbo-spin-echo sequences. Images were read by consensus by 2 experienced raters after consideration of both planes unaware of clinical scores for the presence and location of intrinsic cord changes (e.g. focal lesions, diffuse changes, atrophy). According to the readings each patient was assigned according to a severity score (see Table 2) categorizing for the extent of spinal cord abnormality in 4 severity levels (Fig. 1). The spinal cord abnormality score (SAS) considers the following criteria: i) focal lesions (Fig. 2 a+b), ii) the number of segments of diffuse abnormalities (Fig. 2 e), iii) signs of atrophy (Fig. 2 c+d). Atrophy was rated when it was seen at least in 2 sagittal slices on T2-weighted image and/or obvious deformation/flattening of the shape of the SC in the axial view. Spearman's rank was used to analyze relationships between SAS, EDSS and FSS (Functional system scores = EDSS subscores).

Results: Abnormalities were found in 165/202 (81%) of patients. 37/202 patients showed no pathology (SAS=0). Minimal changes (SAS=1) were seen in 34/202 patients, whereas 60/202 patients were rated with a SAS of 2 (moderate) and 71/202 patients showed more pronounced cord pathology (SAS =3). EDSS showed a strong correlation with the SAS (Spearman-R: 0.55, $p<0.001$). When focusing on motor and sensory FSS subscores, both also correlated with the SAS (motor FSS: Spearman-R: 0.49, $p <0.001$; sensory FSS: Spearman-R: 0.52, $p<0.001$).

Conclusion/Discussion: We present a new approach to categorize spinal cord abnormality in 4 severity levels, that was informative at least in a large cohort of heterogeneous MS patients. It showed good correlation not only between the potentially spinal cord related motor and sensory FSS but also for the EDSS as a total measure of disability. The combination of improved visualization of the typical features of spinal cord pathology with biplanar MRI and their integration in a combined score as suggested may overcome some of the difficulties in the detection and interpretation of SC MRI results. In contrast to previous studies the new score incorporated several different aspects of MS pathology, which might better reflect the actual situation as it is common to find all types of pathology occuring in one subject. Although the image reading is time consuming due to the increased amount of data, this new MRI and analysis approach may be useful when chronic spinal cord abnormality is considered of particular interest.

References:
1. Nijeholt GJ et al. Brain 1998, 2. Trop I et al. AJNR 1998, 3. Kidd D et al. Neurology 1993, 4. Thorpe JW et al. Neurology 1996.

Fig. 1: SAS - Spinal cord Abnormality Score

0	No pathology
1	1-2 focal lesions **or** minimal diffus hyperintensities (< 5 segments)
2	2-5 lesions **or** 1-2 lesions + < 5 segments diffuse changes **or** 5 segments diffus
3	> 6 lesions **or** > 5 diffuse segments **or** focal atrophy*

Fig. 2: