Multiple sclerosis MRI

MRI is the preferred imaging study in evaluating Multiple sclerosis MS and can demonstrate the dissemination of lesions in time and space.

Lesions are normally > 3mm diameter.

MRI shows multiple white matter abnormalities in 80% of patients with MS (compared to 29% for CT).

Lesions are high signal on T2, and acute lesions tend to enhance with gadolinium more than old lesions do. Periventricular lesions may blend in with the signal from CSF in the ventricles on T2; these lesions are shown to better advantage on FLAIR (fluid attenuation) MRI. These lesions are ovoid, are oriented perpendicular to the ependymal surface, and are some- times called Dawson's fingers (after neuropathologist James Dawson).

Spinal cord lesions normally show little or no swelling should be ≥ 3 mm but < 2 vertebral segments, occupy only a portion of the cross-section of the cord and must be hyperintense on T2.

The specificity of MRI is ≈ 94%; however, encephalitis, as well as UBOs seen in aging, may mimic MS lesions. DWI should be normal; however, plaques can sometimes exhibit "shine through", so the ADC map must be checked to rule out infarct.

Focal tumefactive demyelinating lesions (TDL) may occur in isolation or, more commonly, in patients with established MS (often blotchy in appearance, but may appear as bull's-eye targets in Balo's disease AKA concentric sclerosis of Balo). TDL may represent an intermediate position between MS and ADEM.

TDLs tend to be symmetric. TDLs may enhance, and show perilesional edema (but less than MS) and thus be mistaken for neoplasms. Biopsy results may be confusing. MRS may not be able to differentiate from neoplasm.

Segmentation of the spinal cord and lesions from MRI data provides measures of damage, which are key criteria for the diagnosis, prognosis, and longitudinal monitoring in MS. Automating this operation eliminates inter-rater variability and increases the efficiency of large-throughput analysis pipelines. Robust and reliable segmentation across multi-site spinal cord data is challenging because of the large variability related to acquisition parameters and image artifacts. In particular, a precise delineation of lesions is hindered by a broad heterogeneity of lesion contrast, size, location, and shape. The goal of this study was to develop a fully-automatic framework - robust to variability in both image parameters and clinical condition - for segmentation of the spinal cord and intramedullary MS lesions from conventional MRI data of MS and non-MS cases. Scans of 1042 subjects (459 healthy controls, 471 MS patients, and 112 with other spinal pathologies) were included in this multi-site study (n = 30). Data spanned three contrasts (T1-, T2-, and T2∗-weighted) for a total of 1943 vol and featured large heterogeneity in terms of resolution, orientation, coverage, and clinical conditions. The proposed cord and lesion automatic segmentation approach is based on a sequence of two Convolutional Neural Networks (CNNs). To deal with the very small proportion of spinal cord and/or lesion voxels compared to the rest of the volume, a first CNN with 2D dilated convolutions detects the spinal cord centerline, followed by a second CNN with 3D convolutions that segments the spinal cord and/or lesions. CNNs were trained independently with the Dice loss. When compared against manual

segmentation, our CNN-based approach showed a median Dice of 95% vs. 88% for PropSeg ($p \leq 0.05$), a state-of-the-art spinal cord segmentation method. Regarding lesion segmentation on MS data, our framework provided a Dice of 60%, a relative volume difference of -15%, and a lesion-wise detection sensitivity and precision of 83% and 77%, respectively. In this study, we introduce a robust method to segment the spinal cord and intramedullary MS lesions on a variety of MRI contrasts. The proposed framework is open-source and readily available in the Spinal Cord Toolbox [1].

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