A novel Double Inversion Recovery MRI pulse sequence: improved lesion characterization for demyelinating WM and cortical lesions in Multiple Sclerosis?

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Target Audience: MRI scientists/researchers in Multiple sclerosis

Purpose: The detection of cortical lesions in MS with the current most sensitive sequences (DIR) is still suboptimal in detecting cortical plaques of MS. A novel DIR pulse sequence was developed, suppressing GM and CSF (GM-DIR). Designed to detect cortical signal change, we found that also WM lesions have a unique imaging characteristic on this sequence, possibly differentiating demyelinating lesions from other WM pathology. Here we report initial findings in the detection of both cortical lesions (CL) and WM lesions (WML) using this novel DIR sequence.

Methods: Patients with early relapsing-remitting MS were included, age >18 and EDSS < 4. Imaging protocol included 3D standard DIR (WM-DIR, TE/TR/TI: min/5000/2500), DIR suppressing CSF and gray matter (GM-DIR, FSE, TE/TR/TI : min/5000/725 & 2750), and 3D-T1 MPRAGE (TE/TR/TI; 3/7/900, FA: 8, 1.2x1x1 mm) scans (on 3T GE, 8 channel phased array coil). Supratentorial WM lesions were semi-automatically drawn on WM-DIR images. Lesions were identified as having a hypo-intense rim on GM-DIR when minimally of 3 voxels in two consecutive slices were surrounded by a hypo-intense signal change (rim). Therefore, very small lesions (<30 voxels) seen on WM-DIR were not included in the analysis. CL were scored according to consensus guidelines by a board certified neuroradiologist. The distribution, size, imaging characteristics of WML and proportion of CL with signal change on GM-DIR was reported.

Results: Twenty-three patients were scanned (mean age 39.3, SD 11.0). A total of 557 WM lesions were analyzed (median 23 WML/subject (IQR 8-34)). 48% of all lesions had a hypo-intense ring around the lesion, with a median of 51.4% (IQR 27-66%) per patient. Of these lesions, 23% had a heterogenous signal change throughout the lesion, in the majority not seen on WM-DIR or T1. These lesion characteristics were size dependent. Iso-intense lesions had a median size of 55.4 mm3 (IQR 34.9-75.9 mm3), lesions with a hypo-intense rim median size was 107 (IQR 44-169) mm3, and lesions with a hypo-intense rim plus heterogenous signal change were largest, with a median size of 305 (IQR 98-512) mm3. The latter have a unique imaging characteristic with frequently noted lobulated appearance, likely accumulating lesions, which was not visible on standard DIR (figure 1C). Most lesions with a hypo-intense rim were found in the periventricular distribution, where small, iso-intense lesions were most likely to be found in the deep WM. (figure 1, right panel). A total of 222 CL were analyzed. 74.8% of the lesions showed hyperintense signal change compared to the surrounding cortex.

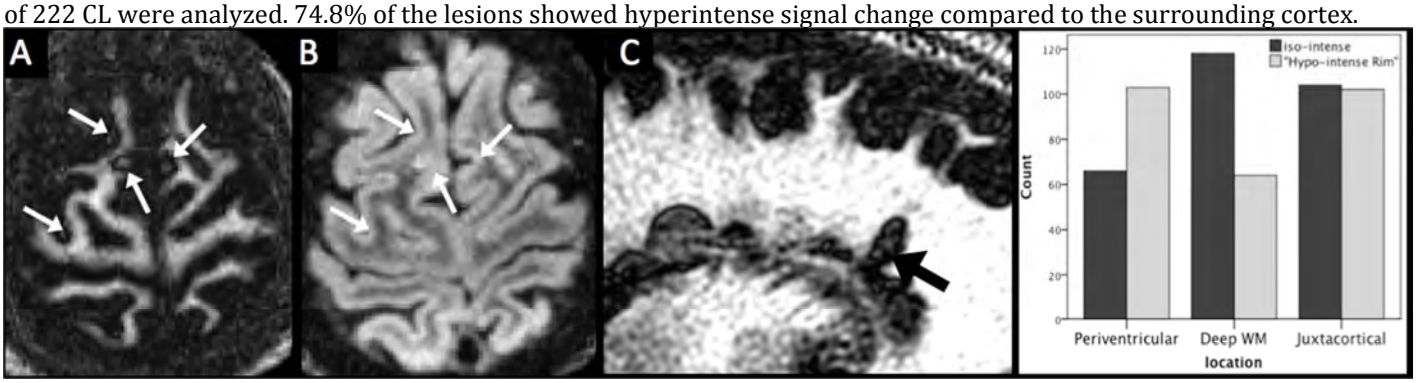

Figure 1: Panel A)GMDIR of cortical lesions, corresponding WM-DIR in (B), heterogenous, multilesional appearing lesion on GMDIR (homogenous on WM-DIR, not shown). Right hand panel shows topographic distribution of the different type of lesions.

Discussion: These preliminary findings suggest that in demyelinating lesions, there is a hypo-intense rim on GM-DIR that is not visible on standard (WM-)DIR. This is possibly dependent on underlying pathological properties and is size dependent. Further studies are needed to investigate the potential pathological and clinical significance of these hypo-intense rims observed on GM-DIR and whether this could have a potential role in differentiating from other WM pathology as well as classify severity of demyelinating plaque. Subtle signal change is observed in the cortex and the combination of GM-DIR and WM-DIR may be beneficial in more sensitive cortical plaque detection. Further studies on control subjects with non-demyelinating WM pathology is underway.

Conclusion: We found a large percentage of lesions that have a unique imaging characteristic on GM-DIR, with a hypo-intense rim surrounding the demyelinating lesion, more commonly found in the periventricular white matter. GM-DIR may be a useful addition to characterization of both CL and WM lesion properties in MS.