Cortical abnormalities in multiple sclerosis by 7T MRI: Novel imaging insights and update

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TARGET AUDIENCE: Scientists and clinicians who are interested in learning ultrahigh field 7T capability in detecting cortical abnormalities that are not available on conventional field strength MRI.

BACKGROUND AND PURPOSE: Histopathological investigations in multiple sclerosis (MS) revealed, that approximately 25% of cortical gray matter (GM), is demyelinated in patients with long-standing disease. Conventional imaging is often failed to detect these cortical abnormalities. Recent advances of ultra-high field (e.g. 7 Tesla) MRI provide superb resolution and contrast and allow markedly improved *in vivo* detection of cortical lesions that are not available on low field MRI[1,2]. A detailed inspection of cortical abnormalities in MS is still highly desirable in both imaging science for better understanding disease mechanism and daily clinical routine for improved correlation with clinical disability. Therefore, the purpose of this study was to update the novel imaging features and insights of cortical abnormalities on 7T MRI.

METHODS: Twenty-one clinically confirmed relapsing remitting MS patients were scanned on a human 7T (Siemens) with a NOVA 24-element head array coil. The imaging protocol included high resolution (in plane resolution: 0.21x0.21 mm^2, slice thickness=2mm) 2D fast low-angle shot (FLASH) T2*-weighted imaging (TR/TE=750/25ms, flip angle=35°), and standard T1-weighted MPRAGE and T2-FLAIR imaging. The abnormal lesion features (i.e. signal, morphology, vascular relationship, location) were carefully investigated on all images including high resolution T2* imaging, which has high resolution and better contrast between cortical gray and white matter.

RESULTS: A total of 31 intracortical lesions were clearly observed on high-resolution susceptibility sensitive T2* GRE imaging, and these lesions are likely corresponding to histopathological type II-IV by Peterson et al[3]. The intra-cortical lesions differed from white matter lesions on 7T and were characterized by *(1)* slightly high intensity than surrounding GM, *(2)* reduced trans-cortical venules within lesions, *(3)* well-demarcated appearance either having gyriform shape (n=17) or small plaques (n=10), and *(4)* inconspicuous sign of "center vein". The most common intracortical lesion type is subpial (type III-IV) lesions that are either diffuse but not involve all the cortical layers (**Fig 1**) or grow along the ribbon and involve all the layers (**Fig 2**). Most white matter origin lesions also showed well demarcated margin. Further, nine patients (43%) showed subcortical hypointense (dark) rim and band-like abnormalities within or around cortical ribbon (**Fig 3**) that are likely associated with vascular abnormalities (ie. hemorrhage), and patients with this type of lesions tend to have more than one lesions with similar appearance.

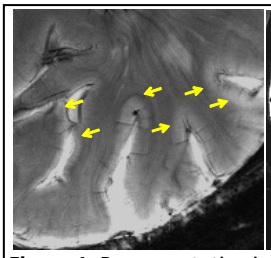

Figure 1. Representative images from two patients showing diffuse and patchy abnormal signal along the cortex, but not involve all cortical layers.

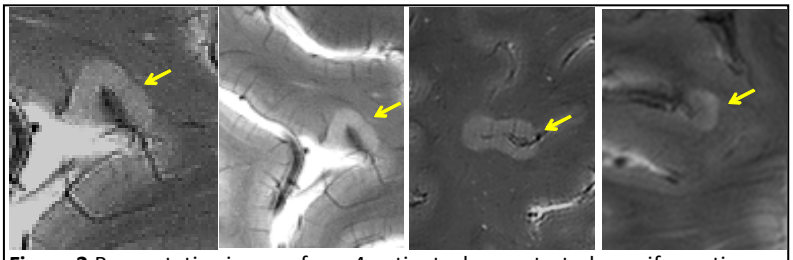

Figure 2.Reprentative images from 4 patients demonstrated a gyriformation type of lesions, which is a unique and common type. Usually they occupy a segment of entire cortex and have slightly higher signal but less cortical venules inside the lesions compared to the surrounding normal appearing cortex.

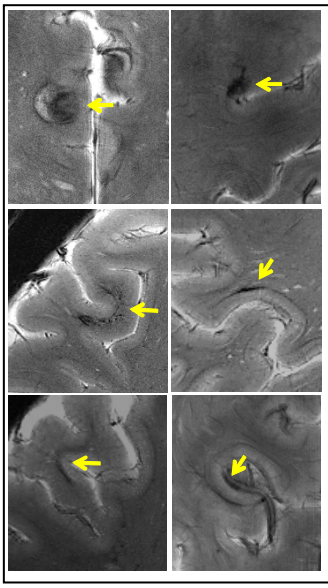

Figure 3. 43% of patients showed abnormal hypointensities within cortex or just beneath cortical ribbon on high-resolution and high susceptibility sensitive T2* GRE imaging. Representative images from six patients in this figure showed different patterns of hypointense lesions, and multiple lesions with similar appearance tend to be seen in one patient. Unlike iron deposition seen in white matter lesions, these lesions likely represent hemorrhagic consequence or vascular abnormalities.

CONCLUSIONS: 7T MRI shows distinctive patterns (as compared to WM lesions) of intracortical lesions, which may provide *in vivo* insights into cortical lesion pathogenesis and development. The small cortical and subcortical hypointense lesions with vascular abnormalities, which are usually not visible at conventional strength MRI, may have important implications of lesion hemorrhagic susceptibility or unfavorable drug effects.

REFERENCES: 1. Mainero C. et al. Neurology 2009; 73:941-48; 2. Pitt D, et al. Arch Neurol. 2010;67(7):812-818. 3. Paterson, JAMA Neurol 2001

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