The utility of ultra-high resolution MRSI on detectability of neurochemical changes in multiple sclerosis-related brain lesions

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Introduction

MRS contributes to classical neuroimaging by providing non-invasive quantification of several brain neurometabolites, which are shown to be related to pathological processes relevant to multiple sclerosis (MS) (i.e., inflammation, demyelination, axonal loss and gliosis). Previous MRSI studies has been severely handicapped by poor spatial resolution (i.e., in-plane voxel sizes ≥10×10mm^2). This is inadequate for investigation of most MS lesions, which are usually much smaller (on average, 6mm in diameter). We aimed to assess the utility of ultra-high resolution MRSI at 7T (i.e., ~2×2mm^2 in-plane) for the detection of metabolic alterations in MS-related brain lesions.

Methods

Twenty relapsing-remitting MS patients (9W/11M; mean age, 30.8±7.7y) were scanned at 7T Siemens scanner with a 2D-FID-based MRSI sequence [1] (TE*=1.3ms) accelerated by parallel imaging [2] (TA<6min) at two spatial resolutions, with 100×100 and 64×64 matrix size (i.e., 2.2×2.2mm^2 and 3.4×3.4mm^2 in-plane voxel size). Additional dataset with matrix size 32×32 (6.8×6.8mm^2 in-plane voxel size) was reconstructed for comparison. Spectra were processed using an in-house developed pipeline, based on Bash, MATLAB, MINC and LCModel. ROIs containing lesions were segmented manually by a radiologist on a corresponding FLAIR image using ITK-Snap. Metabolic maps from all MRSI resolutions and lesion masks were up-sampled to 400×400 resolution for further analysis. Mean metabolic ratios derived for each lesion were compared between the MRSI resolutions.

Results

The mean metabolic ratios in lesions obtained by 100×100 matrix size of MRSI were significantly higher than those obtained by 64×64 matrix size (up to 41% for tCho/tNAA) or by 32×32 matrix size (up to 85% for tCho/tNAA) (*Figure 1*). 83% of the investigated lesions showed increased mIns/tNAA at the 100×100 resolution of MRSI, 66% were visible at the 64×64 resolution, and only 35% at the 32×32 resolution. Examples of mIns/tNAA metabolic maps are shown in *Figure 2*.

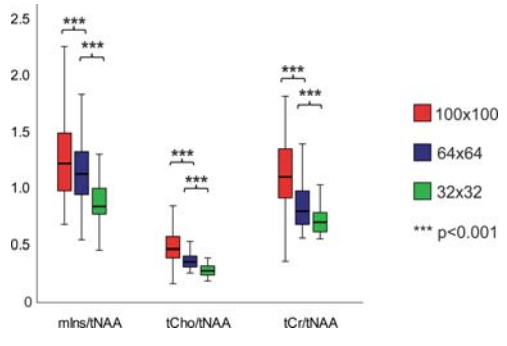

Figure 1: Boxplots with mean metabolic ratios in MS lesions from three different MRSI resolutions.

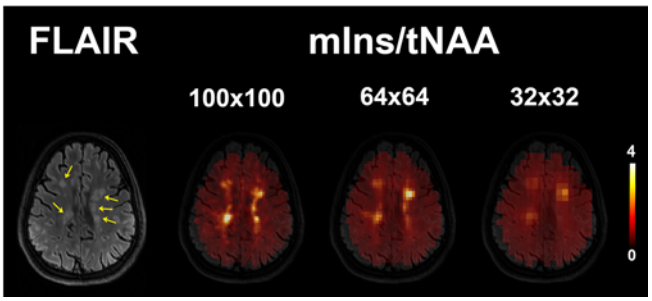

Figure 2: Lower MRSI resolutions are not sufficient for the detection of neurochemical changes in MS-related lesions.

Discussion

Our results show that MRSI with matrix sizes well below 100×100 vastly underestimate the extent of neurometabolic changes in MS lesions due to higher susceptibility to partial volume errors. Metabolic imaging of MS lesions might be beneficial in detecting early stages of lesions development, the detection of active lesions and their progression, as well as more sensitive monitoring under therapy.

Conclusion

Ultra-high resolution MRSI (~2×2mm^2) can detect metabolic alterations in MS-related brain lesions, which cannot be recognized by conventional MRSI resolutions, within clinically feasible times.

References

1. Hangel et al. Neuroimage 2018;168:199-210.
2. Strasser et al. MRM 2017;78(2):429-440.