Improved contrast-to-noise levels for MS lesion detection on CSF-suppressed heavily T_2-weighted imaging

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Target Audience: Radiologists, MR Physicists and Neurologists

Purpose: The standard imaging protocol for MS includes conventional T_2-weighted (T2w) as well as fluid attenuated inversion recovery imaging (FLAIR) (1), which suppresses cerebrospinal fluid (CSF) signal with an inversion pulse allowing for improved visualization of lesions close to CSF, e.g. in the ventricles. Double inversion recovery (DIR) images are advantageous for imaging MS lesions close to or within the cortex (2,3), however, in DIR the utilization of two inversion pulses for the suppression of CSF as well as white matter (WM) signal results in long acquisition times and a low signal-to-noise ratio (SNR). We propose that a combination of 3D FLAIR and 3D T2w images will improve CNR between MS lesions, WM and cortical gray matter (GM).

Methods: 3D T2w and 3D FLAIR scans were acquired in five healthy volunteers (23.4±2.4yrs) and one subject with MS (23yrs). For comparison, DIR images were collected additionally. For SNR and CNR measurements FLAIR and T_2 were collected twice, each consecutively (4). Acquisition parameters were: 3D T_2: FOV=256x256x160 mm^3, TE/TR=363/2500ms, rec. voxelsize=0.8x0.8x0.8 mm^3, acq. time=213s; 3D FLAIR: FOV=256x256x160mm^3, TE/TR=353/8000ms, rec. voxelsize=0.8x0.8x0.8mm^3, acq. time=376s. Halfway registration was performed between the T2w images of each subject, followed by co-registration of both FLAIR images to the T_2 halfway average using FLIRT (5). Multiplying the FLAIR and T2w images yields CSF suppressed, heavily T2w images, here referred to as FLAIR^2. CNR estimations were performed for adjacent GM and WM tissue in healthy volunteers and in tissue with lesion pathology and surrounding normal appearing WM in one MS patient.

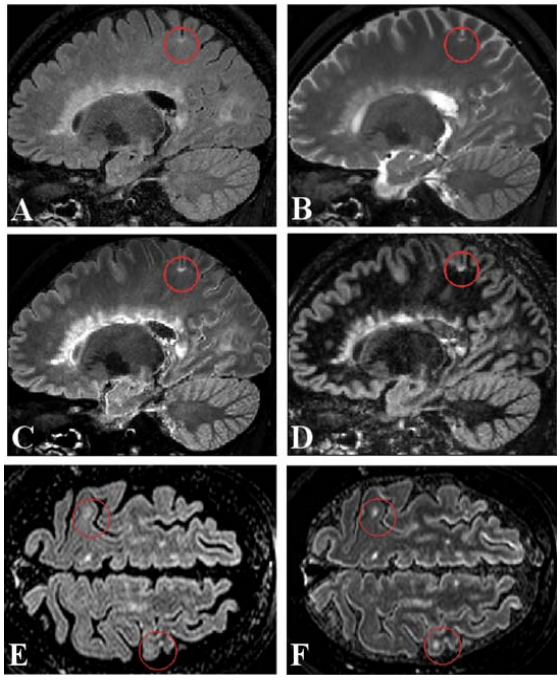

Image	SNR	CNR (GM/WM)	CNR (Lesion/WM)
FLAIR	19.2±1.3	3.6±0.6	2.9±2.9
FLAIR^2	14.8±1.7	7.7±1.0	6.4±6.6

Results: The figure shows FLAIR (A, E), T2w (B), FLAIR^2 (C, F), and DIR (D) images. FLAIR^2 displays improved contrast between GM and WM as well as between lesions and surrounding GM and WM, enhancing visibility and detection of lesion tissue. While the WM signal is less suppressed than with DIR (D), the juxtacortical lesion exhibits similar contrast. The above table summarizes SNR and CNR measurements. SNR of FLAIR^2 is reduced compared to FLAIR, but CNR doubles for GM/WM as well as for lesion and WM. The bottom row of the figure shows FLAIR (E) and FLAIR^2 (F) for a different patient acquired at 1x1x0.8mm^3 spatial resolution. Visibility of lesions adjacent to the cortex is improved in FLAIR^2, with one of them being only visible on FLAIR^2 (red rings).

Discussion: FLAIR^2 achieves a substantial increase in CNR compared to FLAIR, both for GM and WM and lesions and WM. Juxtacortical lesions appeared as prominent on FLAIR^2 as on DIR scans, while lesion contrast was emphasized on FLAIR^2 compared to underlying cortical gray matter. As FLAIR^2 is based on conventional images acquired with most MS protocols, the data for the creation of FLAIR^2 are readily available. The improved CNR of FLAIR^2 may also aid automated lesion segmentation approaches.

Conclusion: An improved visualization of MS lesions can be achieved by combining heavy T_2-weighting and CSF suppression. FLAIR^2 is potentially a new diagnostic tool for the visualization of cortical lesions due to their differentiation from CSF and the lesions' elevated signal compared to the cortical GM.

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