FLAIR-SWI: A combination of 3 Tesla FLAIR and 7 Tesla SWI phase for multiple sclerosis research

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Introduction:

Possible local iron depositions, venous blood vessels and their relation to multiple sclerosis (MS) lesions are a hot topic in MS many research projects [1,2]. Susceptibility-weighted imaging (SWI) is a method in order to visualize local iron depositions and venous blood vessels, but SWI does not provide the clinically known hyperintense definition of MS lesions such as fluid-attenuated inversion recovery (FLAIR) images. Within this work, a combination of 3 Tesla (T) FLAIR and high resolution 7T SWI-phase images called FLAIR-SWI is introduced. The approach of this new contrast is the hyperintense definition of MS lesions overlaid with iron related structures provided by SWI-phase data [1,2]. As FLAIR and T2 imaging is currently due to Specific Absorption Rate (SAR) limits limited at 7.0 Tesla - 3T-FLAIR images were used in order to cover the whole brain.
MS lesions were analyzed with regard to penetrating veins and local iron depositions.

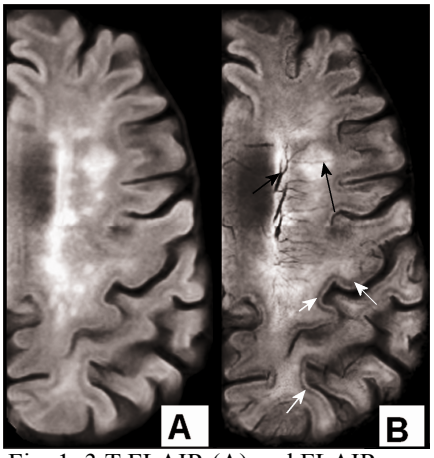

Fig. 1: 3 T FLAIR (A) and FLAIR-SWI (B) of the same slice. Note the additional contrast of veins (black arrows) as well as grey matter (white arrows) in (B).

Materials and Methods:

FLAIR and T1-weighted data from 10 MS patients were acquired at 3T, and at 7T, T1-weighted and SWI data were acquired (data from two patients were because movement artifacts excluded). Before multiplying a phase mask (created from SWI-phase) with the 3T FLAIR data different patient positions in the magnet were corrected using image registration. 3T FLAIR data were registered to 3T T1-weighted data, 3T T1-weighted data were registered to 7T T1-weighted data and finally 7T SWI-magnitude data were registered to 7T T1-weighted data. Afterwards the concatenation of these three transformations was applied to the 3T FLAIR data in order to get it aligned with the 7T SWI phase. Standard SWI image processing was performed except that the transformed 3T FLAIR data was used instead of the SWI magnitude data (Fig. 1).

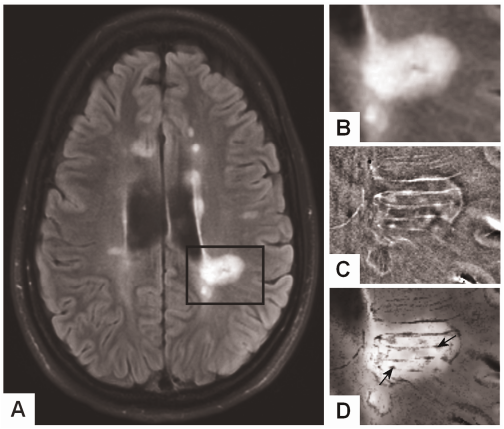

Fig. 2: Information enhancement due to SWI image processing: (A) FLAIR image of an MS patient. (B-D) are subsections of (A). (B) FLAIR, (C) phase and (D) the FLAIR-SWI. Apart from blood vessels, there are also hypointense spots (black arrows) assumed to be inflammation related iron depositions.

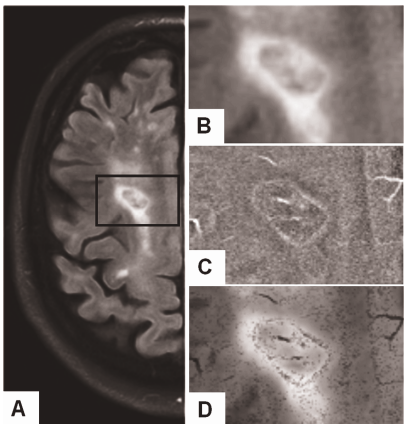

Fig. 3: (A) FLAIR image; (B) sub image of (A; black rectangle); (C) the filtered SWI phase and (D) FLAIR-SWI. (D) shows a rim of increased iron running almost centered within the hyperintense part of the FLAIR image (A, B).

Results:

299 MS lesions were found in eight MS patients. Iron depositions (examples are shown in Fig. 2 and 3) were detected in 48 MS-plaques and penetrating veins were found in 75 MS-plaques. The combination of both (iron depositions and penetrating veins) was found in 44 MS- lesions.

Discussion and Conclusion:

FLAIR-SWI provides radiologically known, hyperintense definition of MS lesions overlaid with information about local iron deposits and venous blood vessels. The data fusion of 3.0 T FLAIR and 7.0 T SWI phase data is robust and gives new insights into MS lesions.

References:

1) Haacke EM. et al. J Magn Reson Imaging 2009;29(3):537-544
2) Hammond KE. et al. Annals of neurology 2008;64(6):707-713.