Improved Contrast and Image Homogeneity with BIR4 Pulses in Magnetization Prepared Flair at 7 Tesla

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Purpose: To improve image homogeneity and contrast of 3D FLAIR images at 7T.

Introduction: FLAIR images with good T_2 weighting can be obtained at 7T if magnetization preparation (MP) is applied prior to inversion [1]. However, the SNR and contrast are still limited in areas where the transmit field amplitude (B_1^+) is reduced or inhomogeneous, such as the temporal operculum, the temporal lobes and the cerebellum (Fig 1a). We hypothesized that the magnetization preparation and the excitation are more sensitive to a low B_1^+ than the turbo spin echo (TSE) refocusing train. Therefore, we implemented magnetization preparation and excitation by adiabatic B_1 insensitive rotation (BIR4) pulses. This work presents the initial results.

Methods: Two healthy volunteers (2 males, 25 and 32 years) were scanned at a 7.0T scanner (Philips Healthcare) with a 16 channel receive coil and a volume T/R coil for transmission (Nova Medical Systems). BIR4 pulses were implemented with amplitude and frequency modulation (AM and FM) as illustrated in Fig 2 and described in [2]. The segmented BIR4 pulse used for the magnetization prepared inversion had a flip angle of 180 degrees. It was implemented as a single pulse with zero amplitude samples between adiabatic half passage (AHP) 1 and 2 and between AHP 3 and 4 to elongate the pulse to 100 ms, needed to induce T_2 preparation prior to inversion [1]. Scan parameters were: FOV 250 x 250 x 180 mm in sagittal orientation, acquired resolution 1.0 x 1.0 x 1.0 mm, turbo spin-echo factor = 125, low refocusing flip angles of 70°, TI 2,675 ms, TR 11,000 ms, TE 250 ms and readout bandwidth 772 Hz/pixel. Scan duration was 12 min. Scans were performed with and without BIR4 pulses, and repeated in both cases with a scan without transmit RF and gradients, to sample noise images for the SNR measurements. B_0 and B_1 maps were also acquired to evaluate the performance of the BIR4 pulses. Images were evaluated regarding SNR, homogeneity of the image intensity and artifacts.

Results and Discussion:

Simulations showed that the used BIR4 pulses have a bandwidth of approximately 2 kHz at 20 µT (nominal B_1) and 1 kHz at 10 µT (50% of nominal B_1). The MP FLAIR images acquired with BIR4 pulses, appeared significantly more homogeneous than the MP FLAIR images without BIR4 (Fig 1). In regions with very low B_1 (approximately 20% of the nominal B_1), the adiabatic condition for the pulse was violated and artifacts were observed, Fig 1e. For these regions, other approaches like B_1 shimming and or new coil design are required to increase the B_1^+ field. The SNR of white matter was approximately 15% less in the image acquired with BIR4 excitation, while gray matter had similar SNR. This is probably due to magnetization transfer effects from the BIR4 pulse. The SNR and contrast in the temporal lobes was considerably improved (Fig 1 c/f).

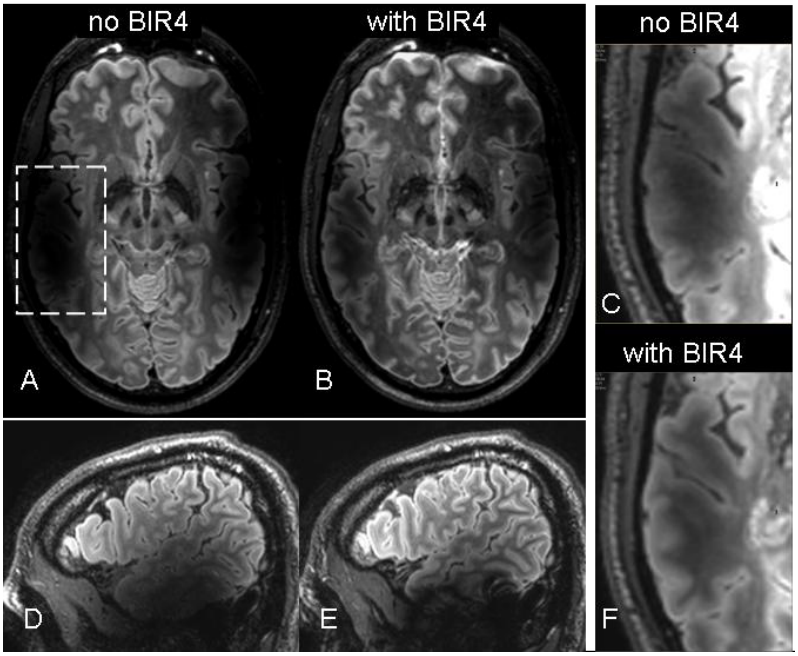

Figure 1. *Magnetization prepared (MP) 3D FLAIR images. A,C,D) images acquired with standard excitation pulses as illustrated in Fig 2. B,E,F) images acquired with BIR4 pulses for excitation, and for the magnetization prepared inversion. Note the lack of contrast in the temporal lobes in the left images, which is considerably improved by the use of BIR4 pulses. E) Some artifacts are visible low in the brain, due to very low B_1 (approx. 20% of nominal B_1). C,F: zoomed details of the temporal lobes in images A,B, showing improved SNR and homogeneity.*

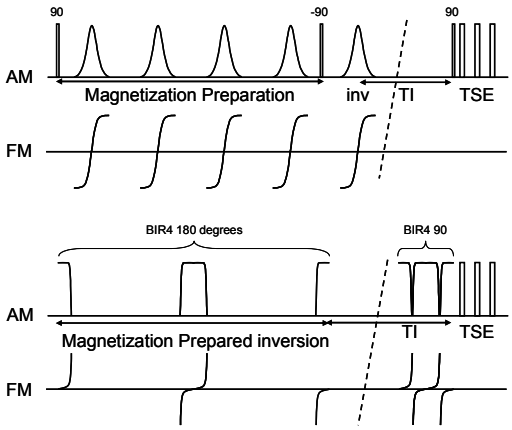

Figure 2. *Schematic drawing of the pulse sequences for standard MP FLAIR (top) and BIR4 MP FLAIR. Using BIR4, the magnetization preparation and the inversion pulse are combined in a single 180 degrees BIR4 pulse, with 'dead time' in between AHP 1 and 2 and AHP 3 and 4 of the BIR4 pulse, to induce the desired magnetization preparation.*

Conclusion: BIR4 pulses for excitation and magnetization prepared inversion can considerably improve the image homogeneity and contrast of FLAIR images at 7 Tesla, in areas with inhomogeneous B_1^+ fields.

References: *1) Visser F, et al. ISMRM 2009, p2760. 2) Garwood M and Ke Y. J. Magn. Reson. 1991, 94:511-525.*