Magnetization-Prepared Segmented FLASH Sequences for High-Field Anatomical Brain Imaging in Animals

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Introduction: Significant developments in magnet technology over the past decade have allowed high resolution 3D imaging of the brain *in vivo* in small animals; however, a challenge is obtaining good gray/white matter contrast. This is because the T_1s for these tissues are less distinct than at low field. As well, the SNR is severely limited by the small voxel size. Therefore, a pulse sequence should produce good signal in the tissues as well as good contrast between them. Here we compare various magnetization-prepared FLASH sequences for high resolution anatomical brain imaging in a marmoset at 7 Tesla.

Modeling: We simulated the signal and contrast produced in gray and white matter by three pulse sequences shown in Figure 1 using existing equations (1, 2). Each sequence used the same segmented FLASH acquisition (tip angle = 12°, TR = 12 ms, matrix = 256 x 256, number of segments = 4). The tissue properties were for marmoset brain at 7 Tesla (T_1 GM/ρ GM = 1800 ms/ 0.75, T1 WM/ρ WM = 1350 ms/0.65). The signal was calculated at the first excitation pulse. The MP-RAGE sequence used a fixed TD of 1600 ms. The preparation time for the MP-RAGE was TD + TI. For the MDEFT it was TI and for the segmented FLASH is was TD. We can see from the results in Figure 2 that MP-RAGE produces the best contrast, but little signal where the contrast is maximized. The MDEFT sequence produces a better signal but a lower contrast. The segmented FLASH produces a high signal at all preparation times, and the contrast becomes good at longer preparation times. The contrast in segmented FLASH is proton-density weighted.

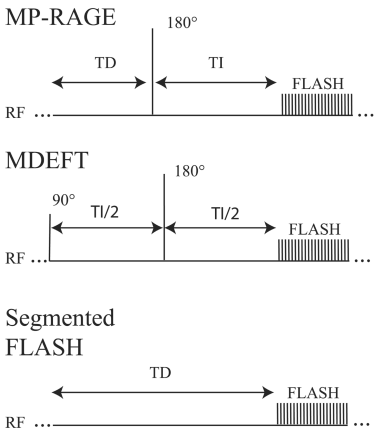

Figure 1.

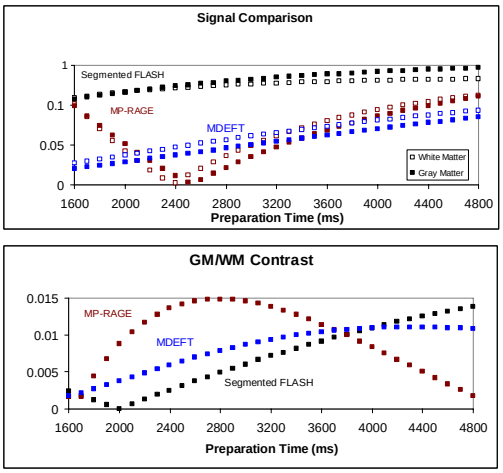

Figure 2.

Methods: A live, anesthetized marmoset was imaged using the MP-RAGE sequence (best contrast) and segmented FLASH sequence (best signal). Imaging was performed on a Bruker 7 Tesla scanner with a Rapid quadrature surface RF coil. Both sequences used the same 3D FLASH sequence for readout (TE = 4.22 ms, TR = 12.38 ms, Matrix = 256 x 256 x 40, FOV = 44.8 x 44.8 x 20.0 mm, Resolution = 175 x 175 x 500 μm, Number of Segments = 4, Averages = 2). The delay time (TD) for the MP-RAGE sequence was 1600 ms and the inversion time (TI) was 1100 ms. The delay time (TD) for the segmented FLASH sequence was 4000 ms. The B_1 field of the surface coil was corrected in both images.

Results: Figure 3 shows the results of the imaging in a coronal slice through the visual cortex and cerebellum. The MP-RAGE sequence took 18 minutes and produced a contrast-to-noise ratio of 3.3 for the gray and white matter in the cerebellum. The segmented FLASH took 25 minutes and produced a CNR of 9.1. For high resolution anatomical brain imaging, the segmented FLASH sequence is advantageous because it produces both high signal and good contrast in gray and white matter.

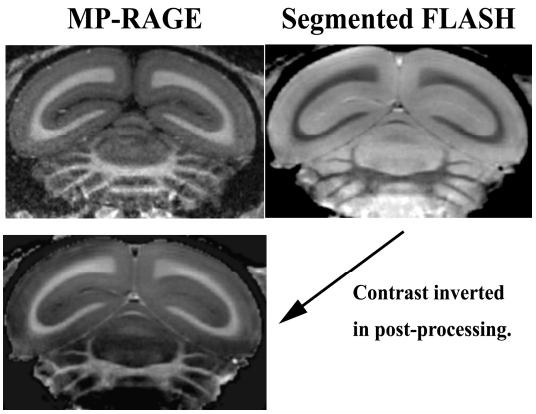

Figure 3.

References:

1. Deichmann R et. al., Neuroimage 2000;12(1):112-127.
2. Deichmann R et. al., Neuroimage 2004;21(2):757-767.