

Magnetic resonance fingerprinting for fetal imaging at 3T - initial results

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Target audience: MR physicists, researchers and clinicians interested in quantitative fetal imaging.

Purpose: Magnetic resonance fingerprinting (MRF) [1] is a novel acquisition and reconstruction technique that enables robust quantitative parameter measurements even in the presence of motion. Fetal imaging on the other hand, has been hindered by unpredictable motion of the fetus which prevents robust and reliable fetal MRI. As a result, fetal imaging in general is limited to fast imaging techniques, like fast single-shot encoding acquisitions, such as Half-Fourier-Acquisition Single-Shot Turbo-Spin-Echo (HASTE). Further, to date, we are not aware of any MRI acquisition method that has given accurate quantification of multiple tissue properties, like T_1 and T_2 constants of the fetal brain and body. The purpose of this study is to employ MRF to fetal imaging, and test its feasibility in obtaining quantitative values of the T_1 and T_2 values in the fetal brain.

Methods: Fetal MRF acquisition was performed on 3T Skyra scanner (Siemens Healthcare, Erlangen, Germany) using a combined 18-channel body and 12-channel spine receive arrays. Spiral trajectories with 48 angular interleaves were designed to traverse (k_x, k_y) and encode a matrix size of 128×128 over FOV = 30cm. With a slice thickness of 5mm, the target voxel size was $2.3 \times 2.3 \times 5 \text{ mm}^3$. Unlike the conventional MRF which uses inversion-recovery (IR) balanced steady state free-precession acquisition (bSSFP), we used inversion recovery fast imaging with steady-state free precession (IR-FISP) in order to get rid of the IR-bSSFP's extreme sensitivity to B_0 inhomogeneities, just like it was shown for MRF applied in the body [2]. The different spiral interleaves were played consecutively in 2000 repetitions, each of them having different TR (8.27ms-10.93ms), TE (4.14ms-5.46ms) and flip angle (0° - 60°). The overall scan time for this single slice acquisition was 20s.

The heavily under-sampled spiral data was reconstructed using gridding [3] and the channels were combined using sensitivity maps estimated from the time-averaged k-space data. Matching was performed across a dictionary containing combinations of 119 T_1 values ranging from [500, 5000]ms and 81 T_2 values from [20, 300]ms.

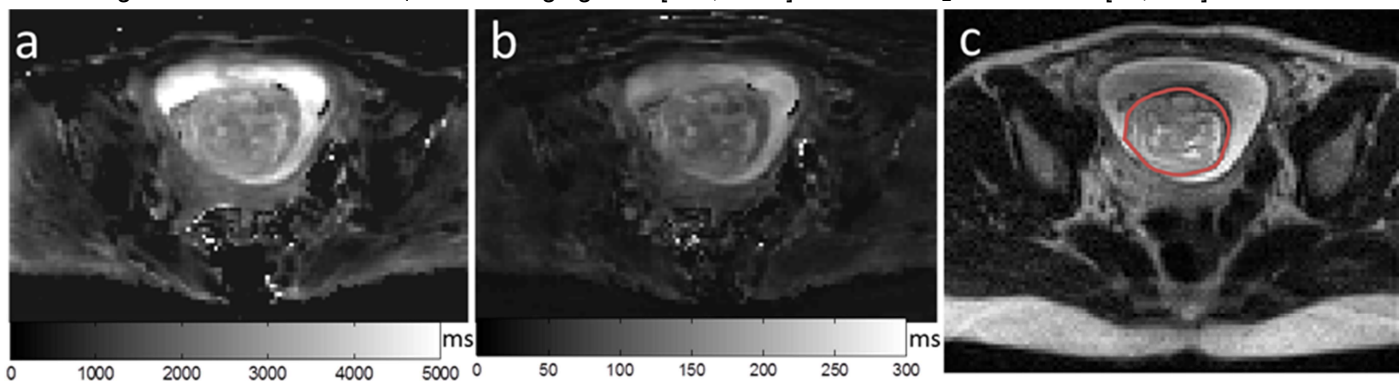


Figure 1: Estimated a) T_1 map and b) T_2 map of a 21 weeks old fetus; c) HASTE scan acquired at the same resolution as the MRF scan. The outline in the image represents the area over which the mean T_1 and T_2 values were calculated

Results: Fig 1a and Fig 1b shows the estimated T_1 and T_2 maps of the fetal brain (21 GA weeks) without any brain abnormalities. Figure 1c shows conventional HASTE image acquired at the same slice location and orientation and at equivalent voxel size as the MRF acquisition ($2.3 \times 2.3 \times 5 \text{ mm}^3$). The estimated mean T_1 and T_2 values inside the brain (hand-drawn mask seen in the HASTE image in Fig 1c) were 2617ms and 102ms, respectively.

Discussion: These fetal MRF results represent the first attempts of FISP-MRF deployment in the fetus. Future improvements include playing spiral trajectories at higher spatial resolution to better differentiate brain structures in the small fetal brain. In addition, the accuracy of the T_1 and T_2 estimates will be improved by correcting for B_1^+ inhomogeneities present in the body. These improvements will be tested in the future studies.

Conclusion: We have shown preliminary results demonstrating the feasibility and potential for employing magnetic resonance fingerprinting (MRF) to fetal imaging for estimation of T_1 and T_2 maps in the fetal brain. Further optimization of the sequence parameters and the complex MRF reconstruction is needed to reliably and robustly produce these quantitative maps. Quantitative parameter mapping via MRF for fetal imaging offers a novel approach to this challenging and clinically important imaging application.

References

[1] Dan M, et al. Nature, 2013, 495:187-193; [2] Chen Y et al. Proc. to 22nd ISMRM, 2014, p561; [3] Fessler et al. IEEE Trans Sig Proc. 2003

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