Inhomogeneity Insensitive MSDE (i2MSDE)
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Introduction: Motion Sensitized Driven Equilibrium (MSDE)1 was originally proposed to achieve satisfactory blood suppression in vessel wall applications. The iMSDE technique was later on found to provide improved image quality at the presence of systemic imperfections, such as B1 inhomogeneity and eddy currents, compared to the traditional MSDE sequence2. With the gaining popularity of large coverage 3D black blood imaging, iMSDE images were also frequently found to present severe signal drop and banding artefacts. This is particularly notable at locations with severe system inhomogeneities, such as the peripheral of FOV in large coverage imaging volumes. Encouraged by recent developments for flow velocity filters in ASL applications3,4, the purpose of this study is to propose and test an inhomogeneity insensitive MSDE (i2MSDE) sequence for black blood imaging that’s even less sensitive to B1/B0 imperfections than the iMSDE technique.

Methods: The i2MSDE pulse sequence diagram and imaging parameters are shown in Fig.1. It achieves the elevated robustness against field inhomogeneity by inserting motion sensitizing gradients into a B1 insensitive rotation (BIR-4) adiabatic pulse5. Assume an ideal gradient waveform, the magnetization (M_z/M_0) level was calculated at different B1/B0 combinations for the i2MSDE pulse, by using numerical simulation of the Bloch equation. A similar simulation was also made for the iMSDE pulse sequence. All MR experiments were conducted on a 3T scanner (Philips Achieva R3.21). In the phantom experiment, a CuSO4 solution phantom with known T1/T2 of 425/340ms was scanned by both sequences using matched m1 values (~1500mTms2/m). Both coronal and axial scans were obtained. The carotid artery of a healthy volunteer (25 M) was scanned by both sequences using matched m1 and acquisition parameters to examine the robustness of both techniques against systemic imperfection. Detailed imaging parameters are: TSE, TR/TE 1100/10ms, TSE factor 12, FOV 160×160mm, Thickness 2mm, Fat Saturation.

Results and Discussion: As shown in Fig.2, the numerical simulation demonstrated that the i2MSDE sequence is more robust against systemic imperfections when compared to the iMSDE. In the phantom experiment, the banding artifacts shown on the iMSDE image at the peripheral of the phantom were completely removed on the i2MSDE images, both on coronal and axial views. For the in vivo comparison, similar results were found. Although the image quality for both techniques was comparable for locations near the center of the magnetic field, severe banding artifacts were found on iMSDE images while not found on i2MSDE images. A quantitative lumen SNR comparison shows no difference between the two techniques.

Conclusion: In this study, an inhomogeneity insensitive MSDE (i2MSDE) sequence was proposed to provide robust black blood image quality for large coverage black blood imaging applications. The i2MSDE sequence was found to provide more robustness against systemic imperfection than iMSDE, through both numerical simulation and phantom experiments. Notable image quality improvement was also found on the in vivo experiments, especially at locations far away from the iso-center of the scanner.