A Simulation Framework to Investigate T1 Contamination on Diffusion Prepared RUFIS

Xin Liu\textsuperscript{1,2}, Florian Wiesinger\textsuperscript{2}, Ana Beatriz Solana\textsuperscript{2}, Tim Sprenger\textsuperscript{1,2}, Miguel Molina-Romero\textsuperscript{1,2}, Pedro A. Gómez\textsuperscript{1,2}, Jonathan I. Sperl\textsuperscript{2}, Bjoern Menze\textsuperscript{1}, Marion I. Menzel\textsuperscript{2}

\textsuperscript{1}Technical University of Munich, Munich, Germany
\textsuperscript{2}GE Global Research, Munich, Germany

1 Introduction

Rotating Ultra-fast Imaging Sequence (RUFIS) is a radial acquisition scheme that allows fast and robust acquisition for magnetization prepared sequences\cite{4}. However, T1-recovery during readout is a common issue for magnetization prepared sequences and introduces unwanted bias. Previous studies reported imaging parameters optimization \cite{3}, RF phase cycling \cite{1} or k-space filtering \cite{1,2} to reduce T1-contamination. In this study, we established a simulation framework to investigate the effect of imaging parameters and RF-cycling scheme on reducing T1-contamination for diffusion prepared RUFIS.

2 Methods

We set up a 3D uniform sphere phantom for simulation, represented by a 163 matrix. The phantom was assigned $T_2=80\text{ms}$, diffusion coefficient $D=10^{-3}\text{mm}^2/\text{s}$ and variable T1 values. We assume a perfect diffusion preparation (duration $T_{\text{prep}}=50\text{ms}$). 256 spokes, 8 data points and $TR=1.5\text{ms}$ for each spoke is assigned for the readout, and encoding matrix is calculated accordingly. The simulated k-space data is multiplied by a weighting function corresponding to the evolution of longitudinal magnetization affected by T1-recovery and repetitive excitation. Algebraic image reconstruction was applied via explicit inversion of the encoding matrix. The diffusion coefficient is calculated based on the model $\log(S/S_0) = -bD$. A region in the central part of the image profile was chosen, and the mean calculated diffusion coefficient $D_{\text{cal}}$ was compared to the input $D_{\text{in}}$. The systematic deviation of measurement is represented in percentage: $\text{DEV} = (D_{\text{cal}} - D_{\text{in}})/D_{\text{in}} \times 100\%$. The impact of flip angle and b-value on the underestimation of $D$, as well as the correction method using phase cycling \cite{1} was investigated.

3 Results

As shown in Fig.1(A), the underestimation of $D$ caused by T1-recovery during readout can be up to 40\% for $b=1000\text{s/mm}^2$, and is more predominant with
increasing b-value, flip angle and decreasing T1. The RF-cycling scheme reduces the bias to be less than 1%.

4 Discussion

Our results confirmed significant underestimation of D caused by T1-recovery in diffusion prepared RUFIS. Unlike turboFLASH in which the problem can be ameliorated by centric phase encoding, in RUFIS the T1-contamination affects the whole k-space. Our results suggest that more accurate measurement can be conducted with lower b value and flip angle, however at the cost of reduced SNR. The RF-cycling scheme eliminates the T1 contamination. The study can be extended for investigating other imaging parameters as well as techniques to reduce T1-contamination.

References