Fat fraction mapping using bSSFP Signal-Phase Amplitude Relaxation Contrast (SPARCQ)

Introduction

A novel approach for quantitation of fat in bSSFP sequences composed of Magnetic Resonance Imaging (MRI) signal profiles (Braun et al., 2010) is reported. It relies on the knowledge that the complex-valued signal profile acquired with a bSSFP sequence is composed of two contributions, one related to the water signal and the other to the fat signal. SPARCQ is based on a novel approach for extraction of the water signal, using a 2-component model. The method is validated in-vivo with a phantom and in-vivo experiments.

Background

The fat fraction can be estimated from the bSSFP signal profile by non-linear fitting of a 2-component model. The water signal is known to be approximately Gaussian in the frequency domain, and the fat signal is highly non-Gaussian. The fat-free water signal is reconstructed from the bSSFP signal profile using a 2-component model of the form: 

\[ A_i = \frac{1}{\sqrt{df_i}} \left[ 1 - \exp(-\pi^2f^2_i) \right] \]

where \( A_i \) is the amplitude at the frequency \( f_i \), and \( df_i \) is the frequency offset from the resonance frequency.

The remaining signal is attributed to fat and the fat fraction is estimated by fitting this model to the measured signal profile. The method is validated in-vivo with a phantom and in-vivo experiments.

Methods

The SPARCQ framework provided accurate and repeatable quantification of water and fat. This may facilitate fat suppression in bSSFP acquisitions and improved quantification of the fat fraction in a non-invasive manner.

Results

The fat fraction estimation is different between the six vials with varying fat fractions. This result is consistent with previous studies and suggests the potential of SPARCQ for other multi-compartment applications.

Discussion

The SPARCQ framework is based on a novel approach for extraction of the water signal from the bSSFP signal profile using a 2-component model. The method is validated in-vivo with a phantom and in-vivo experiments.

Conclusion

The SPARCQ framework is proposed as a novel quantitative method to extract multi-compartmental features, and it provides improved quantification of the fat fraction in a non-invasive manner.

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