Field Map Measurements using a TrueFISP Sequence

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Introduction

A homogeneous static magnetic field (B_0) is essential for many clinical applications requiring TrueFISP imaging. Typically, 3D gradient echo (GRE) sequences are used estimate the B_0-field inhomogeneity. However, these approaches are typically susceptible to motion (such as cardiac or respiratory motion) and flow. In this study, the spectral response function of a TrueFISP sequence was utilized to estimate deviations of the B_0-field. The qualitative features of this response function are largely independent of tissue specific relaxation parameters and the capability of ultra fast 2D multi slice acquisition schemes makes this technique applicable to any body region, including the heart and high-flow regions.

Material and Methods

Frequency Scout

The well known analytical spectral response function of the TrueFISP steady state signal depends on tissue specific relaxation times and sequence parameters such as echo time (TE), repetition time (TR), flip angle θ and the phase ϕ that is accumulated between two consecutive rf excitations [1]. This phase ϕ can be expressed as a function of local field inhomogeneity ΔB: $\phi = \Delta B \bullet TR$. The response function is a symmetrical and periodic function exhibiting local minima (for large θ) and maxima (for small θ) separated by TR/2. A frequency scout sequence was implemented on a clinical 1.5T scanner (MAGNETOM Espree, Siemens AG Healthcare Sector, Erlangen, Germany) that linearly shifts the center frequency of the scanner in a series of TrueFISP images (flip angle θ = 5 DEG).

Field Estimation

The resulting frequency scout images were used to estimate the homogeneity of the main magnetic field. For each pixel or region of interest, a spectral response function was retrieved and analyzed (Fig.1). Qualitative features of the response function such as spectral location of local maxima are largely independent of tissue specific parameters and were used to calculate the shift Δf of the spectral response function as a direct measurement of the local field inhomogeneity: $\Delta B = 2\pi\Delta f/\gamma$. Subsequently, a field map was generated.

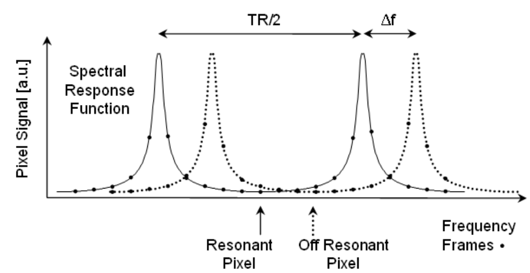

Figure 1: *Spectral response function for a small flip angle 6 and evaluation. For each pixel the shift Δf is calculated using the measured time frames of the frequency scout.*

Volunteer Study

In a feasibility study, frequency scout images have been acquired in different body regions. The image acquisition of the heart was performed in ECG triggered fashion during one single breath hold.

Results

Fig. 2 shows individual frames from a frequency scout of the brain (Fig. 2a: 50 frames, 130x160 matrix, frequency +/-300Hz, TR=3.1ms) using a TrueFISP sequence with a low flip angle (5DEG) resulting in bright banding artifacts. The field map of the brain (Fig. 2b) was obtained by pixel wise calculation of the frequency shift. The cardiac field map (Fig. 2c) was calculated using 30 single shot frequency frames providing smooth field estimations across the heart.

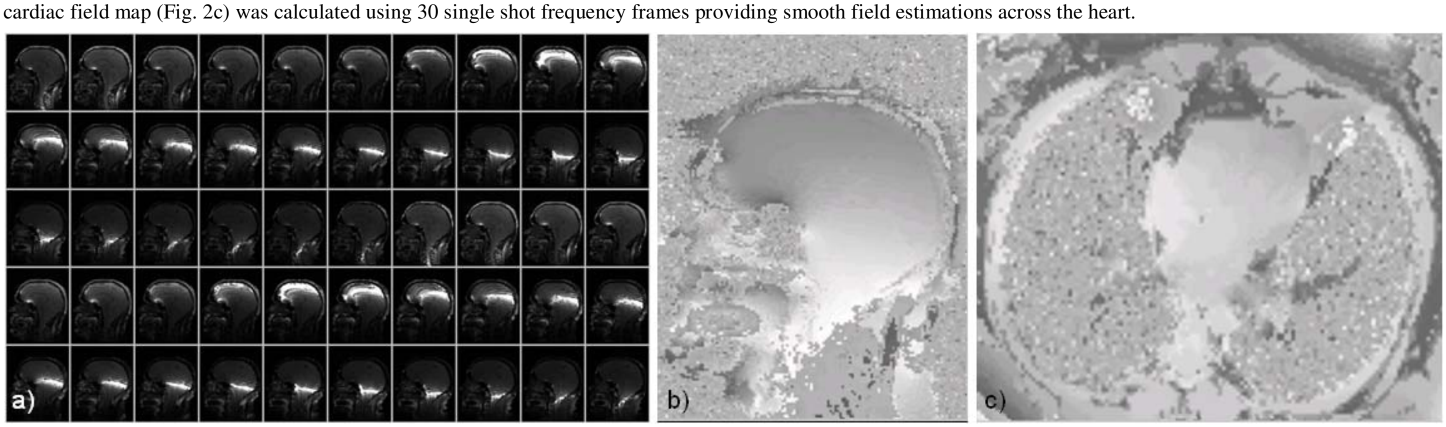

Figure 2: *Frequency scout and derived field maps. (a) Individual frames of a frequency scout using a TrueFISP sequence and (b) resulting field map in the brain (+/-300Hz). The cardiac field map (c, +/-300Hz) was obtained by evaluating triggered frequency scout images in a single breath hold.*

Discussion

Accurate fieldmap estimation using TrueFISP frequency scout was demonstrated *in vivo*. In the presence of fat, however, this estimation may be ambiguous due to chemical shift of fat protons, which is difficult to distinguish from field derivations due to local inhomogeneity. Fat suppression techniques such as fat saturation or spatial spectral excitation pulses require a homogeneous B_0-field. However, a non-selective short inversion approach (STIR) may be used to substantially reduce the signal originating from fatty tissues. The current implementation to estimate the shift of the spectral response function is a peak detection algorithm; accuracy and minimum required number of data points could be optimized by fitting the analytical spectral response function to the measured data points.

References

[1] Haake ME. *Magnetic Resonance Imaging: Physical Principles and Sequence Design.* John Wiley & Sons, chapter 18. (1999)