Quantification of SPIO using T2* and phase imaging

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Introduction

Quantitative assessment of susceptibility imaging is becoming a request in many applications of MRI, such as the sensitive detection of iron oxide particles [Haacke 2005]. To perform susceptibility imaging two main different approaches have been reported in literature, Susceptibility Weighted Imaging (SWI) [Haacke 2004, Hermier 2004] and T2* relaxometry [Politi 2007, Dahnke 2005]. SWI aim is to enhance susceptibility differences by combining T2*-weighted magnitude and phase images. On the other hand, T2* relaxometry calculates T2* maps from multiple gradient echo studies obtained at different echo times. However, most of the studies using these techniques were not particularly concerned with quantification issues. In this work, we have assessed the sensitivity and quantification ability of these techniques by studying the relationship between the measurements obtained using different types of images and the concentration of paramagnetic iron oxide particles in the sample.

Material and methods:

The experiment has been performed using a phantom based on agar with copper sulfate, containing areas with different concentrations of Endorem (Guerbert Laboratories), according to table 1 (Figure 1). The studies were carried out with a Bruker Biospec 70/20 scanner (7T) using a linear coil resonator, employing a multi gradient multi echo sequence (typical parameters: TR, 1500ms; TE, 3 to 58 ms; echo spacing, 5 ms; α 30º; FOV, 7 x 4 cm; matrix, 256x256; slice thickness 1mm).

	Endorem	Agar	$CuSO_4$
1	10 ηg/µl	1%	6mM
2	5 ηg/µl	1%	6mM
3	1 ηg/µl	1%	6mM
4	0.5 ηg/µl	1%	6mM
5	0.1 ηg/µl	1%	6mM
6	0.05 ηg/µl	1%	6mM
7	-	2%	-

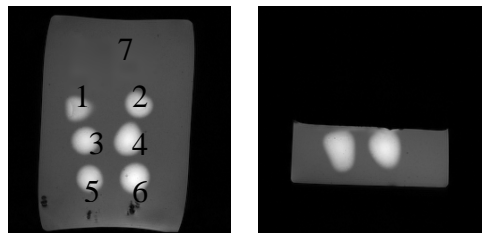**Table 1. Phantom composition**

Figure 1. Coronal and axial views of the phantom (numbers are related to concentrations in Table1)

We calculated the T2* map, as well as the magnitude and phase images from the data acquired. The warping of the phase images was corrected by applying the method described in [Rauscher 2003]. To study the performance of the different images, a contrast measurement was calculated as follows: similar ROIS were traced on each image and their mean values were normalized to the value of the background (2% Agar).

Results

Figure 2 illustrates the relationship between Endorem concentration and the contrast measurement for each type of image. Magnitude images fail to quantify low iron concentrations in the sample, i.e. there are no appreciable contrast differences for different iron concentrations. T2* maps and phase measurements follow similar quantification curves, whereas phase images seem to estimate more linearly iron particle content, until low concentrations are reached.

Conclusions

Although magnitude gradient echo images are used for the visualization of susceptibility differences they hardly provide quantitative results. Alternatively, phase image values result in a linear relation with iron particles concentration, similar to the one obtained with T2* map, while requiring shorter acquisition times, since phase imaging does not require a multiecho acquisition.
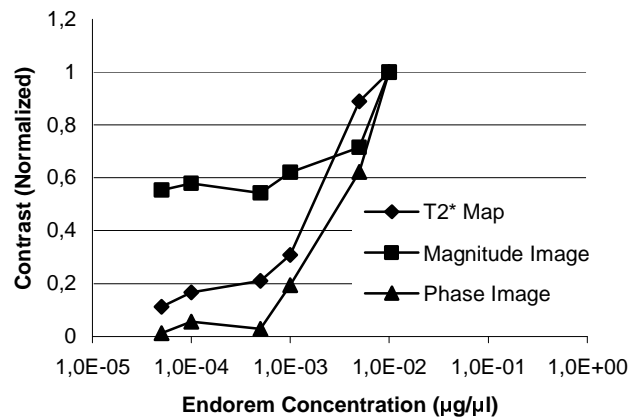

Figure 2. Quantification of Endorem concentrations

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