THE EFFECT OF B1 INHOMOGENEITY ON ENHANCEMENT RATIO MEASUREMENTS USING DCE-MRI OF THE BREAST AT 3T.

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Introduction

Dynamic contrast-enhanced (DCE)-MRI has been proven to be very useful in the diagnosis and prognosis of breast cancer. In the recent years, 3T MR scanners have become more common in routine diagnostic imaging. The main advantage of high field imaging is the improved signal to noise ratio. However, the major drawback is that there is an increased inhomogeneity in radiofrequency transmit (B1) field across the field of view particularly in breast scanning due to the asymmetric position of the patient in the scanner.

Clinically, the analysis of breast DCE-MRI is done using a semi-quantitative method. This is performed by measuring the signal enhancement ratio (ER) in a chosen region of interest after contrast agent infusion.

\[ ER = \frac{S_{\text{post}} - S_{\text{pre}}}{S_{\text{pre}}} \times 100\% \quad \text{Eq. 1} \]

where \( S_{\text{pre}} \) and \( S_{\text{post}} \) are the signal intensities measured on the images obtained before and after the arrival of contrast agent in the tissue [1]. Since signal intensity is a function of flip angle (\( \alpha \)) and hence B1 transmit field, it will be affected by the B1 inhomogeneity. The aim of our study is to investigate the error in ER which arises from this variation in B1. We chose to perform a phantom study instead of a numerical approach because we found that at a very short TR the signal intensities have a poor agreement with the FLASH equation, probably as a result of incomplete RF spoiling of transverse magnetisation.

Methods

Using a Philips Achieva 3T scanner and a seven channel breast coil (Philips Medical Systems, Best, the Netherlands) the B1 field was measured by imaging five healthy volunteers in the axial plane. A B1 map was produced using proprietary B1 mapping (based on the “actual flip-angle imaging” [2] pulse sequence). To simulate pre- and post-contrast breast tissue, a set of gel phantoms with different T1 values was constructed (T1=380, 580, 890, 1010 and 1330ms).

To accurately simulate the effect of B1 inhomogeneity on images of the gel phantoms a uniform B1 field amplitude across the field of view particularly in breast scanning due to the asymmetric position of the patient in the scanner. A B1 map was produced using proprietary B1 mapping (based on the “actual flip-angle imaging” [2] pulse sequence). To simulate pre- and post-contrast breast tissue, a set of gel phantoms with different T1 values was constructed (T1=380, 580, 890, 1010 and 1330ms).

Discussion

Breast DCE-MRI at 3T suffers from B1 inhomogeneity problems. For high field axial scanning, the B1 field is reduced at one side relative to the other. This causes variation in the enhancement ratio. From Fig. 2, it can be observed that for 100% contrast enhancement, a value often taken as the “true” value, the ER shows that the amplitude of ER decreases as the B1 field reduces and increases slightly with B1 field stronger than the optimal field.

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Results

A typical plot of the B1 field variation across the axial plane is shown in Fig. 1. B1 field can be seen to vary from around 50% to 110% of the desired B1 across the field of view. The ER as a function of difference in relaxation rate (\( \Delta R1 \)) for three simulated B1 fields is shown in Fig. 2 (where \( \Delta R1 \) considered to be proportional to contrast agent concentration during DCE-MRI). The figure shows that the amplitude of ER decreases as the B1 field reduces and increases slightly with B1 field stronger than the optimal field.

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Fig. 1 A profile plot showing a typical B1 inhomogeneity for an axial scan of the breast performed on a volunteer at 3T.

Fig. 2 Enhancement ratio as a function of \( \Delta R1 \) for three B1 values, where \( \Delta R1 \) is the differences in relaxation rate (1/T1) before and after the arrival of contrast agent in the tissue.

References


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