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 (B_1) 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. The *ER* is calculated using:

$$ER = \frac{S_{post} - S_{pre}}{S_{pre}} x 100\% \qquad \text{Eq. 1}$$

where S_{pre} and S_{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 (α) and hence B_1 transmit field, it will be affected by the B_1 inhomogeneity. The aim of our study is to investigate the error in *ER* which arises from this variation in B_1. 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 B_1 field was measured by imaging five healthy volunteers in the axial plane. A B_1 map was produced using proprietary B_1 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 T_1 values was constructed (T_1=380, 580, 890, 1010 and 1330ms).

To accurately simulate the effect of B_1 inhomogeneity on images of the gel phantoms a uniform B_1 field amplitude across the field of view was required. Hence, imaging was performed using a quadrature head coil and a 3D T1-FFE sequence (TR/TE/α:10ms/2.3ms/35^o). The flip angle of 35^o was chosen as it produces a good linear response and sufficient signal to noise ratio over the range of T_1s found in breast tissues. To simulate the B_1 inhomogeneity effect α was changed to 16^o and 54^o which represents 46% and 154% of B_1 field relative to the desired B_1. These values were chosen to cover a wide range of B_1 inhomogeneity to compare to our measurement of B_1 inhomogeneity. Assuming that the T_1 of ductal tissue is approximately 1330ms [3] the enhancement ratio was calculated for each phantom at each α using Eq. 1. Here T_{1pre} is taken to be the phantom with T_1=1330ms and T_{1post} is each of the shorter T_1 phantoms.

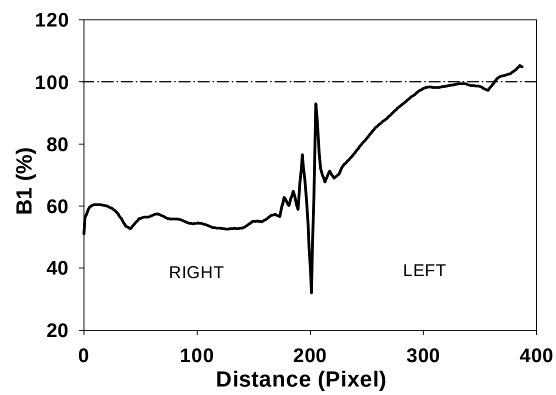

Fig. 1 A profile plot showing a typical B_1 inhomogeneity for an axial scan of the breast performed on a volunteer at 3T.

Results

A typical plot of the B_1 field variation across the axial plane is shown in Fig. 1. B_1 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 (ΔR_1) for three simulated B1 fields is shown in Fig. 2 (where ΔR_1 is 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 B_1 field stronger than the optimal field.

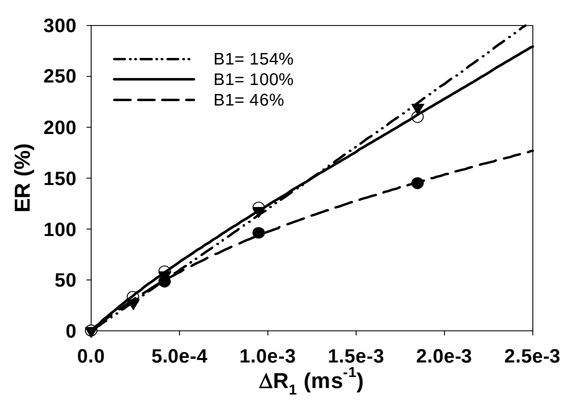

Fig. 2 Enhancement ratio as a function of ΔR1 for three B_1 values, where ΔR_1 is the differences in relaxation rate ($1/T_1$) before and after the arrival of contrast agent in the tissue.

Discussion

Breast DCE-MRI at 3T suffers from B_1 inhomogeneity problems. For high field axial scanning, the B_1 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 minimum *ER* indicating possible malignancy [4] , a 54% reduction in B_1 will cause a reduction of *ER* by 20% from the "true" value. Fig. 2 shows that the differences are greater at higher ER values. However, increases in the RF pulse angle in areas of increased B_1 transmit field do not greatly alter enhancement ratio at the RF pulse angle we have chosen. Therefore, the use of a flip angle larger than 35^o might be useful to reduce this effect at the expense of a reduced contrast to noise ratio and increased SAR. We conclude that clinicians should be aware and consider this issue during the analysis of DCE-MRI images of the breast at 3T.

References

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