Evaluation and Optimisation of the Acquiring Combined Echoes (ACE) sequence for localised proton Magnetic Resonance Spectroscopy of the breast

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INTRODUCTION

Breast Cancer is the most common form of malignancy worldwide and the second biggest killer of women. The current philosophy with regard to tackling this problem is to reduce mortality through early detection [1]. Currently the most common methods of detecting and quantifying breast cancer are mammography and biopsy respectively. MRS has the advantage over these in that it is non-ionising and non-invasive. It also combines the detection and quantification in a single exam. Using non-invasive Magnetic Resonance spectroscopy (MRS) techniques, increased amounts of the common nutrient choline are observed in vitro in breast tumours. Pulse sequences currently used are limited for choline detection, as fat and water dominate the choline region of the spectrum. Frequency selective sequences, such as Acquiring Combined Echoes (ACE), allow suppression of the unwanted water and fat signals and improve detection of choline in vivo. Van Vaals [2] et al. implemented ACE on a high field strength scanner in 1991. Although workers have proposed using ACE for breast, it has not been tested in a clinical scanner [3].

MATERIALS & METHOD

The purpose of this research was to optimise and evaluate the ACE sequence for a phased array breast coil on a 1.5T magnet and to compare different sequences and coils for performing breast MRS. The ACE sequence was adapted in house for use on a clinical scanner. Pulse sequences were constructed using the Siemens 'Pargen' pulse programming language and RF pulses were imported from the 'Matpulse' software platform. During the research, the STEAM, PRESS and ACE sequences were tested on both the single and phased array coils, using phantoms containing varying choline concentrations (20mM – 0.25mM). Experiments performed in this study included the determination of phantom T1 and T2, SNR measurements as well as coil and sequence comparisons. A qualitative Observer study was also carried out. The phantoms used in this study had a T1 value of 1429ms and a T2 value of 324ms. These values are comparable to the T1, T2 values quoted in the literature [4, 5].

RESULTS

SNR Measurement - in all cases showed improved SNR on Phased Array Coil. See Table 1.

Coil Comparison – Phased Array Coil proved to be the superior of the two for Breast MRS. These results can be seen in Figure 1.

Sequence Name	**Single Array Coil**	**Phased Array Coil**
STEAM	0.02	0.39
PRESS	0.23	0.32
ACE	0.32	0.5

TABLE 1: SNR for each sequence / coil combination

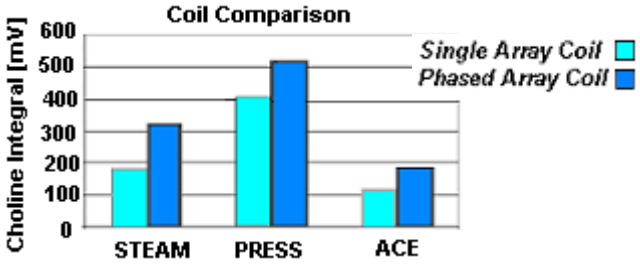

FIGURE 1: Coil Performance

Sequence Comparison

At high choline concentrations PRESS and STEAM give the best results with PRESS outperforming STEAM in this range due to the higher SNR it provides. However ACE outperforms the STEAM sequence at 1mM concentration and it is the only sequence of the three capable of detecting choline below 1mM on both coils. It is in this low choline concentration range that ACE shows its true potential.

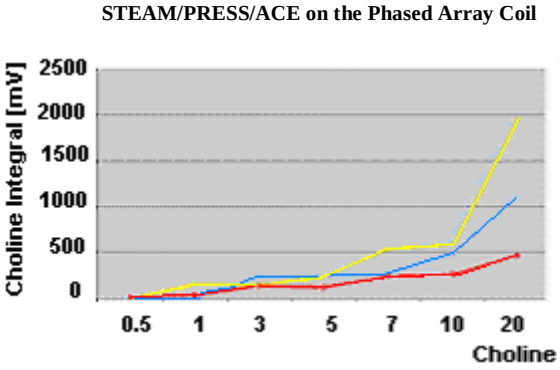

FIGURE 2: Sequence Comparison

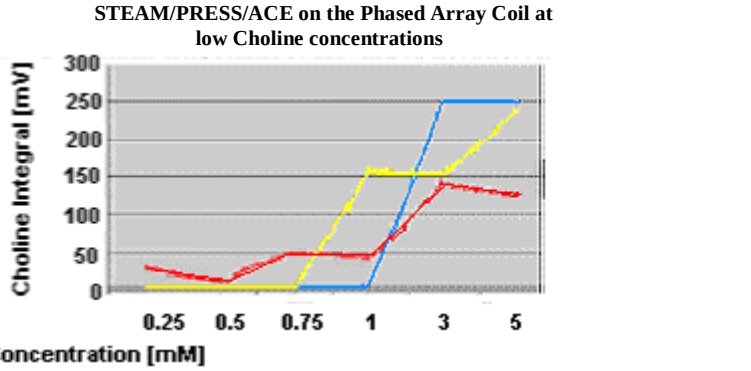

FIGURE 3: Sequence Comparison at Low Choline Concentrations

Blinded Observer Study

The observers graded scans of 5, 3 and 1mM choline phantoms. The single array results were in general poor. Improved results were obtained from the phased array section of the study, where the scores displayed increasing discernability in accordance with the increased choline concentration. The ACE sequence on the phased array coil received the best score for this study with the 5mM phantom in this group unanimously receiving a maximum score of 5.

CONCLUSIONS

The results of the phantom study showed that at low choline concentrations the in house ACE sequence outperformed both the conventional STEAM and PRESS sequences on the phased array coil. Before clinical introduction the ACE sequence needs to be tested in vivo and the effect of various homogeneities, also require investigation. However based on this research, it is felt that ACE on the phased array coil holds much promise for use in clinical practice.

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