Modulated Flip Angle Single Shot Fast Spin Echo: A Potential Means for Rapid T2W Breast Imaging

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Target audience: MR researchers, breast radiologists, oncologists, breast clinicians.

Background: Breast MRI has a number of clinical indications [1]. The global demand for breast MR examinations is growing and this represents a significant burden on limited healthcare budgets. Guidelines have been introduced in an attempt to standardise breast MR acquisition [1, 2]. Nevertheless, there are many protocol options to choose from and examination times tend to be lengthy (typically ≥30 minutes). Increasing demand, coupled with lengthy examination times is neither desirable nor sustainable. Consequently, there is a desire to develop breast MR protocols with shorter examination times.

Traditionally, in breast MRI, a fast spin echo (FSE) technique has been utilised to acquire fat saturated T2W images. Single shot FSE (SSFSE) represents an ultrafast pulse sequence where efficiencies in scan time could be made for T2W images. In SSFSE, following the initial RF excitation, all the lines of k-space are acquired for an individual slice. However, SSFSE sequences utilise very long echo train lengths (ETL), which are associated with strong blurring in the phase encoding direction due to T2 decay. Refocusing flip angle modulation [3] has recently been utilised with SSFSE pulse sequences, providing several benefits, including faster acquisitions and the potential for improved sharpness by limiting signal modulation due to T2 decay [4].

Purpose: To develop a fat nulled T2W flip angle modulation SSFSE protocol and compare the resulting images with a fat saturated T2W FSE technique.

Methods: Phantom, volunteer and patient breast MR examinations were undertaken on a 3.0T MR750 scanner in conjunction with the manufacturer's 8-channel breast coil (GE Healthcare, Waukesha, WI, USA). Following phantom and volunteer development work, SSFSE with flip angle modulation were acquired on patients with the following parameters: axial, 2D, TR/TE 1000/87ms, FOV 36x36cm, slice 4mm, gap 0mm, matrix 288x224 bandwidth 83.3kHz, NEX 2, ASSET acceleration x3, scan time 70 seconds and spectrally selective inversion recovery fat nulling with a TI of 170ms combined with bilateral shim volumes. Refocusing flip angle targets [3], were 130, 60, 100, and 45 degrees, respectively, allowing full-Fourier acquisition with the above parameters. Traditional FSE T2W images were also acquired for comparison: axial, 2D, TR/TE 7000/108ms, FOV 36x36cm, slice 4mm, gap 0mm, matrix 288x224, bandwidth 41.7kHz, NEX 2, scan time 2 minutes 55 seconds and chemical shift selective imaging sequence fat suppression.

Results: Phantom experiments revealed superior signal-to-noise (SNR) ratios for SSFSE (SNR=280) compared to FSE (SNR=160). Flip angle modulated T2W fat nulled SSFSE images were successfully acquired in 2 volunteers and 8 patients. Comparison T2W FSE images were obtained in 4 cases. Images were reviewed by a breast radiologist in terms of image quality and preservation of T2 information. While flip angle modulation SSFSE demonstrated slightly reduced overall image quality compared to the FSE technique the SSFSE images were assessed to be comparable with FSE in terms of T2 information. Figure 1 demonstrates typical results from both flip angle modulation SSFSE and FSE techniques note superior fat nulling and minimal blurring for SSFSE.

Discussion: SSFSE images are known to provide excellent T2 information in a very short acquisition time, however, previous SSFSE implementations were associated with excessive image blurring limiting their application. Utilising a flip angle modulation scheme in combination with SSFSE results in a number of benefits. SAR and therefore repetition time can be reduced. Additionally, modulating refocusing flip angles allows for improved sharpness by way of full-Fourier acquisition and reduced signal modulation due to T2 decay.

Conclusions: Flip angle modulated T2W fat nulled SSFSE images can be acquired in 70 seconds and provide radiologists with the same T2 information available in longer FSE based T2W sequences. Consequently, SSFSE could be utilised to reduced breast MR examination times.

References: [1]Mann MR et al. Eur Radiol. 2008;18:1307-1318. [2]ACR 2013.www.acr.org/~/media/ACR/Documents/PGTS/guidelines [3]Busse RF et al. MRM 2008;60:640-649. [4]Saranathan M, et al. ISMRM, Milan, 2014, #2175.

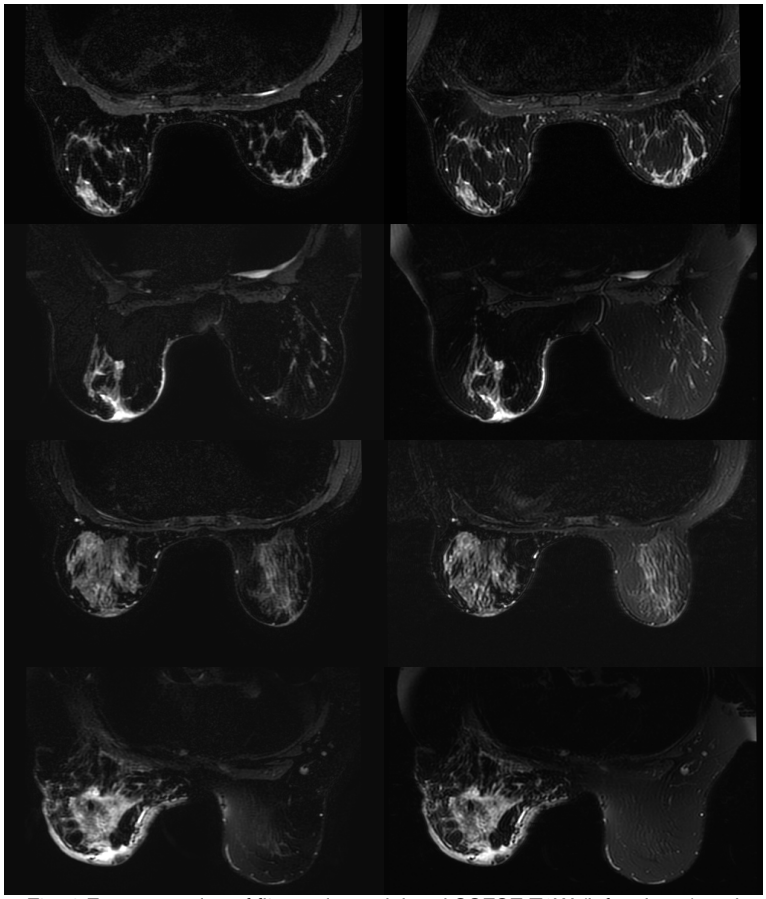

Fig. 1 Four examples of flip angle modulated SSFSE T2W (left column) and FSE T2W (right column) axial images.