Development of a T2 Weighted 3D CUBE Inversion Recovery Fat Nulled Sequence for Breast Imaging

Martin D Pickles[1], Peter Gibbs[1], Ersin Bayram[2], Donglai Huo[2], and Lindsay W Turnbull[1]

[1]Centre for MR Investigations, University of Hull, Hull, East Yorkshire, United Kingdom, [2]GE Healthcare, Waukesha, WI, United States

Introduction While breast MRI has a recognised high sensitivity the specificity of the technique is somewhat lower. Consequently, techniques that can distinguish between malignant and benign lesions are necessary to increase the specificity. T2W fat nulled sequences help to differentiation lesions since, in general, benign processes (cysts, edema, myxoid fibroadenomas and inflammation) have a higher signal intensity than malignant lesion on T2W sequences. However, accurate assessment of lesions requires high spatial resolution images. Currently, T2W fat nulled images are normally acquired via a 2D FSE imaging strategy. However, this scheme can result in i) a long scan time since multiple planes of acquisition may be necessary, ii) suboptimal fat saturation since traditional CHESS pulses are susceptible to incomplete fat saturation due to B_0 inhomogeneities, particularly when large FOV's are utilised and in the presence of complex tissue-air interfaces as found in breast fold areas, and iii) images without the required spatial resolution and incomplete imaging of the whole tissue due to the slice gap nature of 2D imaging.

We propose a 3D T2W FSE technique combined with an IR pulse that will result in high spatial resolution images with uniform fat suppression in a clinically acceptable acquisition time.

Methods A pulse sequence was developed that utilised CUBE FSE in combination with an IR pulse. CUBE FSE is a 3D sequence that applies modulating refocusing flip angles. Traditionally, in FSE sequences long echo train lengths result in blurred images. This occurs since the later echoes are acquired when considerable T2 decay has occurred. Modulating the refocusing pulses flattens the T2 decay curve, subsequently, long echo train lengths can be employed to acquire 3D data without resulting in i) excessive acquisition times or ii) blurred images. The CUBE pulse sequence also provides ARC, a self calibrating acceleration technique, in two directions (phase and slice) combined with a partial Fourier sampling scheme to further reduce scan times. By combining an IR pulse with CUBE a more robust fat nulling is achieved since IR techniques are insensitive to B0 inhomogeneities. 3D sagittal CUBE IR imaging of both breasts in one series were performed at 3.0T with the following parameters: TR/TE/TI 2500/78.5/250ms, FOV 28x28cm, slice 2.4mm, matrix 320x320, voxel size 0.875x0.875x2.4mm, ETL 90, BW 62.5kHz, NEX 1, scan time ~ 5min20sec. A comparison between traditional 2D sagittal T2W FSE techniques (TR/TE 6000/107, FOV 20x20cm, slice/gap 3.6/0mm, matrix 384x288, voxel size 0.521x0.694x3.6mm, ETL 19, BW 41.67kHz, NEX 2, scan time ~ 3min per breast) and 3D T2W CUBE IR was undertaken in a small cohort of patients scheduled for breast MR.
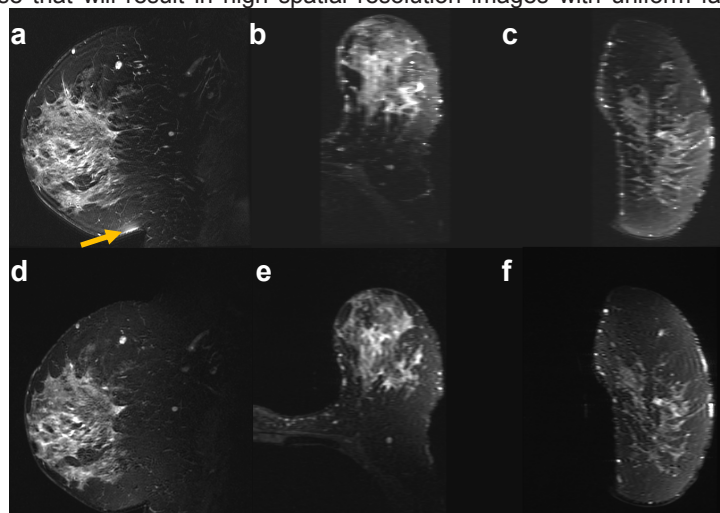

Fig. I. Top row: sagittal 2D FSE fat sat source data (a), axial reformat (b), coronal reformat (c). Bottom row: sagittal 3D CUBE IR source data (d), axial reformat (e), coronal reformat (f).
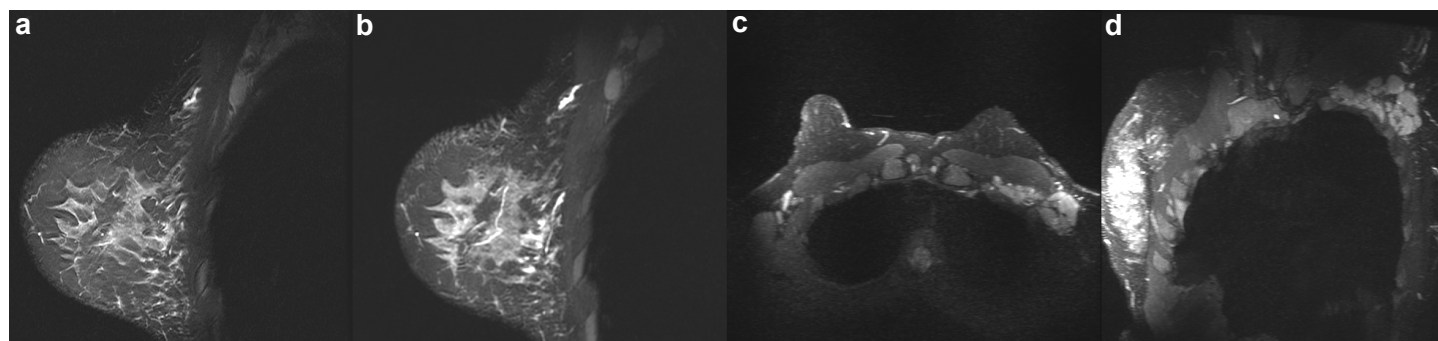

Fig. II. Sagittal 2D FSE fat sat (a), sagittal 3D CUBE IR (b), axial reformat CUBE IR (c), oblique reformat CUBE IR. Note extensive lymphadenopathy. Reformat images help to fully describe relationship between lesions and surrounding anatomy

Results 3D T2W CUBE IR datasets were successfully acquired in 10 patients. Robust fat nulling combined with high spatial resolution was noted in all cases. Figure I compares the results of traditional 2D T2W FSE images (arrow indicates poor fat sat) with 3D T2W CUBE IR. Figure II demonstrates the usefulness of multiplanar reformatting along with benefit of robust fat suppression extending to the surrounding anatomy in a region with significant B_0 inhomogeneities. In addition due to the use of modulating refocusing flip angles the sequence is less sensitive to motion related artifacts, note lack of cardiac related artifacts in the thorax.

Conclusions By combining 3D CUBE FSE with an IR pulse, robust T2W fat nulled images can be acquired in a clinically acceptable imaging time (~5min) for both breasts as opposed to traditional 2D sagittal FSE techniques (3minutes per breast plus prescan ~7min). Additionally, these images can be reformatted into any desired plane further increasing the efficiency of the technique and thereby providing improved comparison against volumetric DCE-MRI data.