Clinical Experience of Acquiring Both High Spatial and High Temporal Resolution Breast Dynamic Datasets Utilising a Differential Subsampling with Cartesian Ordering k-space Acquisition Scheme

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

Purpose: The requirement for short temporal resolution to characterise the initial enhancement rate and high spatial resolution to assess morphological detail, represent a challenge for breast MR dynamics. Morphological information is essential for image interpretation and diagnostic accuracy [1, 2]. Ideally high spatial resolution morphological detail should be acquired when the image contrast between enhancing lesions and breast parenchyma is expected to be at a maximum, normally ~2 minutes post contrast injection [1,2]. Given that the initial enhancement rate of a lesion has been demonstrated to hold important information related to diagnosis [3], treatment response [4] and prognosis [5], the functional dynamic information should be acquired with a temporal resolution fast enough to characterise this rate. Additionally, dynamic information should allow characterisation of the delayed contrast kinetics. Uniform nulling of the fat signal represents another important challenge for breast MR, particularly at higher field strengths over large FOVs due to inhomogeneous B_0 and B_1 issues [6].
DIfferential Subsampling with Cartesian Ordering (DISCO) is a new k-space acquisition scheme that has recently become commercially available. This scheme allows the acquisition of both high spatial and high temporal resolution images in the same MR sequence. Furthermore DISCO utilises a two point Dixon technique wherein both in-and-out of phase images are acquired followed by the processing of water-and-fat only images. Water only datasets produce images with uniform fat nulling over large FOVs. Moreover, the prescan insensitive nature of the Dixon acquisition improves workflow by obviating the need for any manual shimming or manual prescan which could add to the exam time and rely on operator expertise.
The aim of this work is to report initial clinical experience of DISCO dynamic breast examinations.

DISCO theory: DISCO samples k-space in an elliptical fashion [6,7]. The elliptical shaped k-space is divided into central and outer portions. The outer portion of k-space is segmented into an adjustable number of equal distributions regions via a pseudo-random segmentation scheme [7]. The central portion of k-space is sampled every temporal frame while the outer edges are subsampled sequentially [7]. Temporal resolution is minimised by using view-sharing [6]. The adoption of pseudo-random segmentation disperses the motion artefacts [6,7]. If the central portion of k-space is represented by A and the 3 equal distributed regions of the outer edge of k-space are represented by B_1, B_2 and B_3 then the typical k-space sampling scheme would initial start with a pre contrast mask (A, B_1, B_2 and B_3) followed by AB_1, AB_2, AB_3, AB_1,…

Methods: DISCO dynamic breast series were undertaken on a 3.0T MR750 scanner in conjunction with the manufacturers 8 channel breast coil (GE Healthcare, Waukesha, WI, USA). A 3D T1W two point Dixon DISCO sequence was employed with the following parameters: TR/TE_{op}/TE_{ip} 4.1/1.1/2.3 ms, flip 10°, FOV 350x392mm, slice 1.8/-0.9mm, matrix 360x360, locs. 128, BW 200kHz, NEX 1, ARC acceleration 2.0, voxel volume 0.97x0.97x0.9 = 0.85mm^3, temporal resolution 33.7 seconds per phase (initial mask phase 1 minute 18 seconds), total number of phases 11.

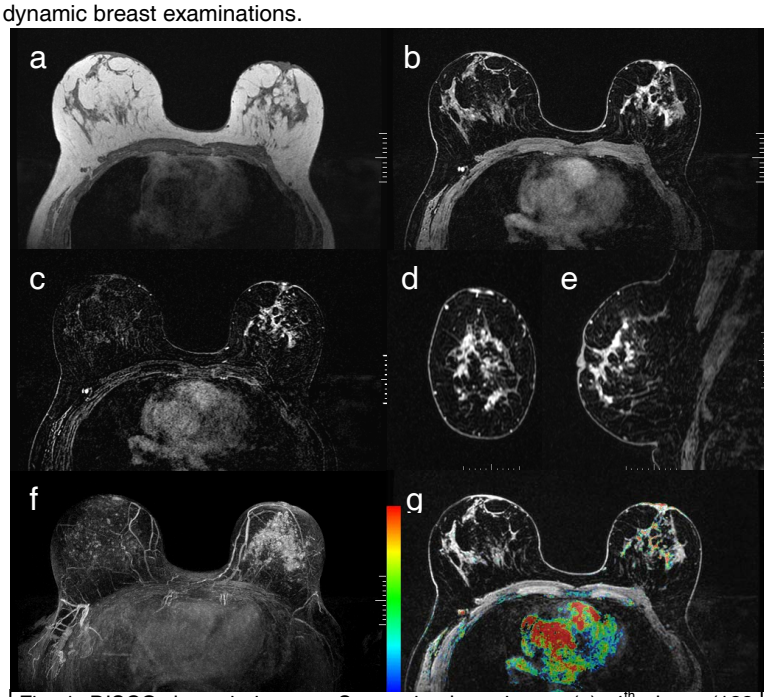
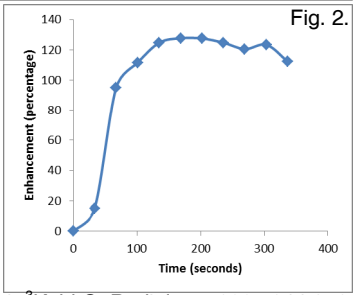


Fig. 1. DISCO dynamic images. Source in-phase image (a), 4th phase (132 seconds post contrast) water only image (b), subtracted (4th phase – pre contrast) image (c), coronal (d) and sagittal reformatted images (e), MIP from subtracted dataset (f), positive enhancement integral overlaid onto source water only image (g).

Results: DISCO based DCE-MRI was successfully acquired in 20 individuals. Fig. 1 demonstrates the ability of the sequence to acquire high spatial resolution (voxel 0.97x0.97x0.9mm) images capable of reformatting into any desired plane. Additionally, the high temporal resolution (~34sec) is also apparent in the resulting signal intensity uptake curve (Fig. 2). Two point Dixon reconstruction resulted in excellent fat nulling in all cases even with the combination of a large FOV and high field strength. As a comparison our previous dynamic sequence obtained with a two point Dixon sequence without DISCO resulted in a temporal resolution of 30 seconds but resulted in an almost doubling of voxel volume (0.99x0.63x2.5 = 1.54mm^3) compared to that achieved with DISCO.



Conclusions: Our initial clinical experience indicates that DISCO dynamic breast examinations not only result in robust fat signal nulling but also achieve both high spatial and temporal resolution within the same sequence. Consequently, clinicians will not have to bias their dynamic sequence to either spatial or temporal resolution.

References: [1]Mann MR et al. Eur Radiol. 2008;18:1307-1318. [2]Macura KJ et al. Radiographics. 2006;26:1719-1734. [3]Kuhl C. Radiology. 2007;244:356-378. [4]Padhani AR and Khan AA. Targ Oncol. 2010;5:39-52. [5]Dietzel M, et al. JMRI. 2013;37:146-155. [6]Saranathan M et al. JMRI. 2012;35:1484-1492. [7]Hope TA et al. JMRI. 2013;38:938-945.