TRICKS Based DCE-MRI: a Potential Route to Both High Spatial and High Temporal Resolution Breast Dynamic Datasets

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Introduction The ideal breast DCE-MRI sequence should provide both high temporal and high spatial resolution. Subsequently, the resulting signal intensity uptake curve should more accurately match the real physiological tissue pharmacokinetics. Likewise, the resulting morphological images should be a truer representation of the tissue under examination. However, high temporal and high spatial resolution images are usually mutually exclusive. In this work, we demonstrate proof of principle that both high spatial and high temporal resolution DCE-MRI images can be acquired by combining a breast optimised 3D T1W sequence with time resolved imaging of contrast kinetics (TRICKS).

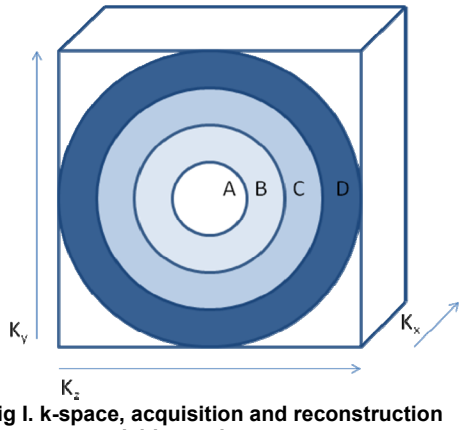

Fig I. k-space, acquisition and reconstruction
k-space acquisition order
A_0 B_0 C_0 D_0 A_1 B_1 A_2 C_1 A_3 D_1 A_4 B_2 A_5 C_2 A_6 D_2...
k-space reconstruction for individual phases
Mask: A_0, B_0, C_0, D_0
Phase 1: A_1, B_0 B_1, C_0 C_1, D_0 D_1
Phase 2: B_1, A_1 A_2, C_0 C_1, D_0 D_1
Phase 3: A_2, B_1 B_2, C_0 C_1, D_0 D_1...

TRICKS Theory k-space can be divided into low and high spatial frequencies. Within k-space low spatial frequencies contain information related to the broad signal of the image while high spatial frequencies relate to the fine detail of the image. TRICKS utilizes variable rate k-space sampling, in this implementation k-space is divided into four regions (A-D), initially (mask phase) all regions are sampled once, thereafter A is sampled every second phase while B-D are undersampled. By incorporating view sharing and temporal interpolation images of a high temporal and spatial resolution can be reconstructed from the acquired k-space segments (Fig. I.)

Methods A pulse sequence was developed that combined elliptic centric TRICKS with a breast optimised 3D T1W gradient echo sequence employing a Shinnar-Le Roux spectral spatial pulse resulting in B_1 insensitive water only excitation. The resulting 3D axial sequence was acquire on a 3.0T scanner with an 8 channel breast coil with the following parameters: TR/TE 6.7/3.4 ms, flip 12^O, FOV 36x36cm, slice 2.8/-1.4mm, matrix 360x360, voxel 1.0x1.0x1.4mm, locs. 72, BW 125kHz, NEX 0.5, temporal resolution 10 sec per phase (initial mask phase 40 sec). To demonstrate proof of principle this newly developed sequence was tested without contrast to assess image quality. Following successful testing the sequence was employed to acquire DCE-MRI data in individuals undergoing breast MR.

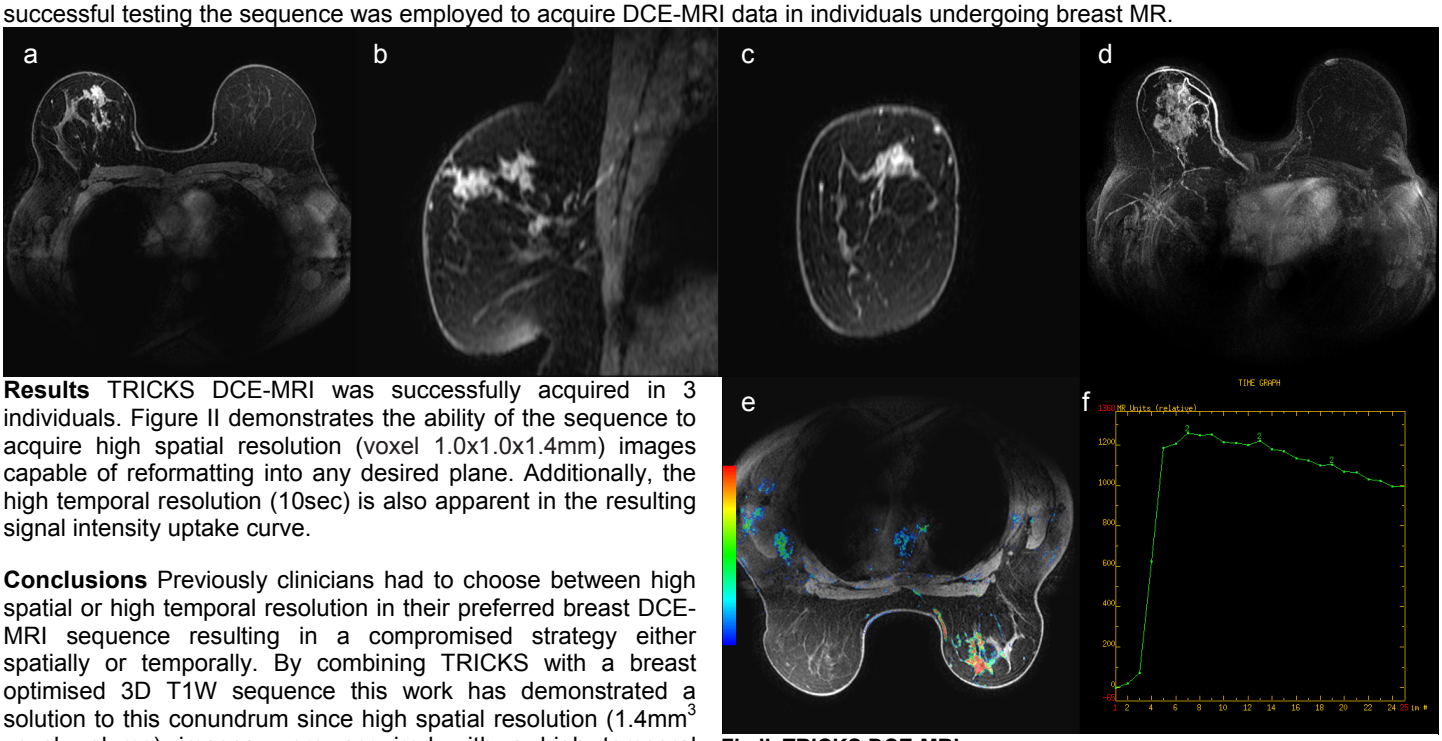

Fig II. TRICKS DCE-MRI
Source axial data 5th phase (a), sagittal (b) and coronal reformats (c), maximum intensity projection (d), source data with max. enhancement slope overlay (e), signal intensity uptake curve (f)

Results TRICKS DCE-MRI was successfully acquired in 3 individuals. Figure II demonstrates the ability of the sequence to acquire high spatial resolution (voxel 1.0x1.0x1.4mm) images capable of reformatting into any desired plane. Additionally, the high temporal resolution (10sec) is also apparent in the resulting signal intensity uptake curve.

Conclusions Previously clinicians had to choose between high spatial or high temporal resolution in their preferred breast DCE-MRI sequence resulting in a compromised strategy either spatially or temporally. By combining TRICKS with a breast optimised 3D T1W sequence this work has demonstrated a solution to this conundrum since high spatial resolution ($1.4mm^3$ voxel volume) images were acquired with a high temporal resolution (10sec).

Future Work To reduce any sensitivity to B_0 inhomogeneities dual shim volumes (one per breast) will be implemented within the prescan to ensure accurate shimming and centre frequency calculations. Further, phase FOV > 1 will help to reduce memory consumption whilst maintaining coverage and spatial resolution. Once implemented additional data will be collected and assessed from the improved pulse sequence.