Multiecho 2-Point Dixon (mDIXON) Imaging as an Alternative to Separate 2D Chemical Shift Imaging and 3D Fat-Suppressed T1-weighted Sequences for Gadolinium Enhanced Imaging

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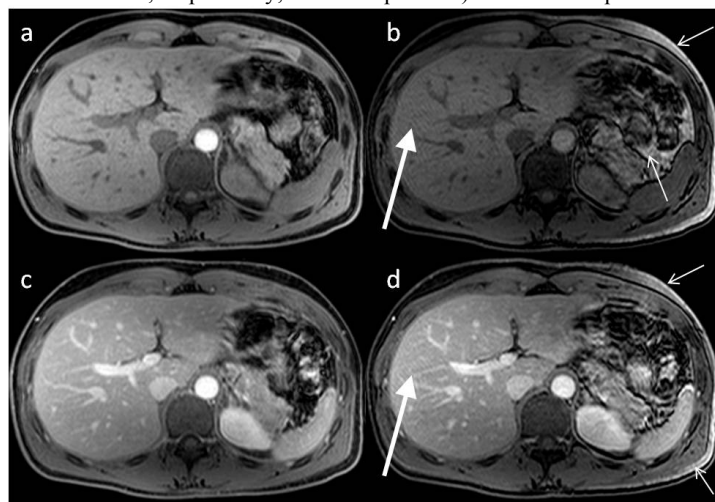
Introduction Routine clinical magnetic resonance imaging (MRI) of the abdomen employs different T1-weighted (T1W) techniques, including in-phase (IP) and out-of-phase (OP) dual echo 2D gradient echo (GRE) (e.g. fast field echo (FFE)) sequences for detection of intravoxel fat[1] and 3D fat-suppressed (FS) spoiled GRE (SPGR) sequences for dynamic contrast enhanced (DCE) imaging[2]. The dual-echo 2-point Dixon (mDIXON) technique developed by Eggers et al[3] allows for more efficient fat/water separation by selecting two echo times irrespective of the relative phase of water and fat protons. The feasibility of this technique to produce images with acquisition times, resolution, and fat exclusion comparable to or better than conventional 3D FS T1W GRE images while eliminating the need for separate 2D chemical shift imaging has been shown.[4] The purpose of this study was to rigorously compare mDIXON to our previous standard dual echo 2D FFE and 3D T1W SPGR (eTHRIVE) techniques on the basis of relative signal and contrast, homogeneity of fat exclusion, tissue plane definition, and presence of artifacts.

Materials and Methods Nineteen patients (age 56±33) underwent dynamic MRI of the abdomen using a 16-channel torso phased-array coil on a single 3.0-T system (Achieva; Philips Healthcare, Best, Netherlands). Breath-held pre-contrast dual echo axial 2D IP and OP T1W FFE images (TR/TE1/TE2=180/1.15/2.3 ms, voxel size=2.0x1.48x7 mm^3, 1 mm gap, 20.9 s x 3 acquisitions) and 3D eTHRIVE images (TR=3.2/1.49 ms, voxel size = 1.7x1.99x4 mm^3, sense factor of 2, 19.5 s acquisition) were acquired. eTHRIVE images were also acquired dynamically after administration of gadolinium (0.1 mmol/kg body weight) during the arterial, portal, venous, and equilibrium phases. 3D mDIXON images (TR/TE1/TE2=3.2/1.1/2.0 ms, voxel size=1.7x1.99x4 mm^3, sense factor of 1.7 and 1.5 in phase and slice direction, respectively, 16.9 s acquisition) were also acquired before

and immediately after the eTHRIVE images, and reconstructed as IP, OP, water only, and fat-only imaging data sets. Pre-contrast mDIXON-derived IP and OP T1W images were reformatted into 7 mm axial images. _Quantitative analysis:_ Region-of-interest (ROI) analysis was performed by one radiologist on pre-contrast 2D dual-echo versus mDIXON-derived IP and OP images; pre-contrast eTHRIVE versus mDIXON water-only images; and delayed post-contrast eTHRIVE versus mDIXON water-only images. A saline filled tube served as reference standard and was used to calculate relative signal intensities in ROIs. "Signal relative to standard" (SRS) was defined as $SI_{organX}/SI_{standard}$ for the liver, spleen, and pancreas; and "relative contrast ratio" (RCR) between the liver and spleen, the pancreas and spleen, and between renal cortex and medulla was defined as $|SI_{organX} - SI_{organY}|/SI_{organY}$. _Qualitative analysis_ was also performed with the same data sets by three other independent reviewers who were blinded to patient and sequence information. Image quality was assessed by scoring the following parameters on a scale of 1–5 (5=highest quality): sharpness of liver edge, sharpness of renal edge, homogeneity of fat signal exclusion, and image degradation due to artifacts. Statistical analysis was performed using SAS 9.2 (SAS Institute, Gary, NC) with linear mixed models and generalized linear models of SRS/RCR measurements and subjective scoring variables, respectively, to detect differences between mDIXON and our previous standard techniques. The generalized estimating equation method was employed to estimate model parameters. P-values<0.05 were considered significant.

Comparison of mDIXON pre (a) and postcontrast (c), versus eTHRIVE pre (b) and postcontrast (d) images. Note inhomogeneous fat suppression (small arrows) and banding artifacts (large arrows) on the eTHRIVE images.

Results. _Quantitative Analysis:_ mDIXON was statistically superior in seven of eight calculations of SRS and RCR (except RCR postcontrast) (Table). _Qualitative Analysis:_ mDIXON was superior to eTHRIVE for homogeneity of fat exclusion (odds ratio 188 for precontrast and 36 for postcontrast images; p-value <0.001); and image degradation from artifacts (odds ratio 5.3, p-value <0.001 for precontrast; odds ratio 2.5, p=0.0064 for postcontrast) (Figure). However, 2D IP and OP images were superior to mDIXON in image degradation evaluation (odds ratio 0.25, p=0.0021 for IP; odds ratio 0.40, p= 0.0001 for OP). There were no statistically significant differences for edge definition between mDIXON and eTHRIVE (pre and postcontrast) or 2D IP and OP images (p-values ranging from 0.1254-0.9329).

Discussion and Conclusion The mDIXON sequence provides a viable alternative to standard 2D and 3D T1W imaging techniques. The time advantage of deleting the separate 2D IP and OP images is small, but not insignificant in an environment of ever increasing pressure to maximize efficiency. The improved through plane resolution of the 3D technique also allows for more reliable characterization of small lesions such as small adrenal adenomas. Moreover, the decreased breath hold duration in the mDIXON sequence compared to an eTHRIVE scan of similar resolution allows greater confidence in obtaining a motion free exam. In light of these advantages, the improved relative signal and contrast, improved homogeneity of fat exclusion, and the reduction of image degradation from artifacts are compelling arguments in favor of mDIXON.

mDIXON vs. Std. Sequences			
SRS	estimate	Std dev	p-value
1 diff_ip	0.2572	0.05306	0.0001
2 diff_op	0.2465	0.04229	<.0001
3 diff_post	0.2247	0.05939	0.0014
4 diff_pre	0.1132	0.04122	0.0132
RCR			
1 diff_ip	0.08299	0.02961	0.0118
2 diff_op	0.09304	0.03398	0.0135
3 diff_post	0.00600	0.01824	0.7458
4 diff_pre	0.07823	0.03756	0.0518
Differences in signal relative to standard (SRS) and in relative contrast ratio (RCR) between mDIXON and 2D FFE for in-phase (IP)(1) and out-of-phase (OP) (2) images; and between mDIXON and eTHRIVE on pre(3) and post (4) contrast images.			

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