# Clinical Feasibility of a 3D Dual Echo Dixon Technique For Abdominal MRI

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**Introduction:** Separation of fat and water has been shown to improve diagnostic capabilities of MR, particularly for identifying regions of fatty infiltration and adrenal adenomas. Conventional 2D dual echo sequences typically limit the acquisition to relatively thick slices (~8mm) for adequate liver coverage within a breath-hold. Most abdominal imaging protocols also include a fat-suppressed 3D T1 weighted acquisition to obtain high-resolution dynamic contrast-enhanced images; however, current 3D sequences can acquire only a single echo and thus do not offer the benefits of dual echo imaging. Furthermore, the success of fat suppression in 3D sequences is highly dependent on field homogeneity. A 3D dual gradient echo imaging sequence has recently been developed that permits the acquisition of both in-phase and out-of-phase images within a single breath-hold. This dual-echo can be combined with a two-point Dixon technique with a novel phase correction algorithm to decompose water and fat images [1]. This combination of techniques, known as MEDAL (**M**ulti-**E**cho acquisition with 2-point Dixon Reconstruction for **D**ecomposition of **A**qua/**L**ipid) permits the possibility of achieving robust fat-suppressed, water-suppressed, in-phase, and out-of-phase images within a single breath-hold. This work investigates the clinical application of 3D MEDAL imaging to abdominal body MRI, specifically comparing 3D MEDAL with the 3D LAVA sequence, as well as with multiplanar SPGR in-phase/out-of-phase imaging.

**Methods:** A 3D dual gradient echo imaging pulse sequence was developed to acquire two echoes within the same TR in sequential mode. The echo time was designed to be as close to the 1.5T fat/water opposed-phase (2.3ms) and in-phase (4.6ms) values as possible for the prescribed readout resolution. Image acquisition was accelerated in both phase- and slice-encoding directions using 2D parallel imaging. An online two-point Dixon image reconstruction with a novel phase correction algorithm [2] was used to decompose water-only and fat-only images from the dual-echo acquisition. Native in-phase (water+fat) and out-of-phase (water-fat) images were also reconstructed resulting in a total of 4 images per location. Typical imaging parameters were: matrix 320x224x68, BW=+/-83 kHz, flip angle=12˚, slice thickness=4.4mm, FOV=36cm, scan time=20s.

After obtaining informed consent, prospective imaging of the abdomen and/or pelvis was performed on 15 randomly selected patients. All patients were imaged on the same 1.5 T whole-body scanner (Signa®HDx, GE Healthcare, Waukesha, WI) using both MEDAL and LAVA (Liver Accelerated Volume Acquisition- T1-weighted fat-suppressed 3D spoiled gradient echo) sequences. Typical imaging parameters for LAVA were: matrix 320x224x68, BW=+/-62.5 kHz, flip angle = 12˚, slice thickness=4.4, FOV 36 cm, scan time=20s. Only sequences with identical anatomic coverage and similar contrast phases were selected for review. Multislice subsets of the volumes were anonymized, randomized, and reviewed by two blinded radiologists. Comparisons were made between the LAVA and water-only MEDAL sequences for quality of fat saturation, artifact/noise level, image sharpness, and overall preference. Comparisons were also made between the MEDAL in/out-of-phase images and conventional multiplanar SPGR in/out-of phase images. Typical imaging parameters for in/out-of-phase multiplanar SPGR sequences were: matrix352x256x40, BW=+/-32kHz, flip angle=80˚, slice thickness=10.0mm, FOV=36cm, scan time=32s. MEDAL images were reformatted to similar slice thicknesses. Radiologists were asked to evaluate artifact and noise level, sharpness, and overall preference. Average scan times were also compared.

**Results:** After blinded review of images, fat saturation quality was deemed nearly perfect on the MEDAL water-only images. Noise level was also perceived to be less on the MEDAL water-only images. Overall, there was no significant difference in perceived sharpness or artifact level between the two image sets. Preference for technique varied between radiologists. While radiologists prefered the multiplanar SPGR in/out-of-phase images in comparison with the equivalent MEDAL image pairs, when questioned, the radiologists felt that clinical diagnostic ability would not be significantly hampered by using the MEDAL in/out-of-phase images. The summed average scan time for both LAVA and multiplanar SPGR sequences was 57 seconds, in comparison with average scan times of 23 seconds for acquisition of all of the MEDAL images, for an average reduction in scan time of approximately 60 percent.

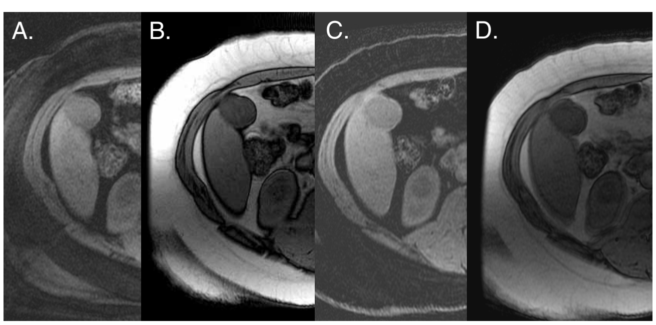


**Figure 1.** 37 year-old female with exophytic microscopic fat-containing hepatic FNH. Comparison of LAVA pre-contrast and conventional out-of-phase (A and B, respectively) with MEDAL water-only and MEDAL out-of-phase images (C and D, respectively).

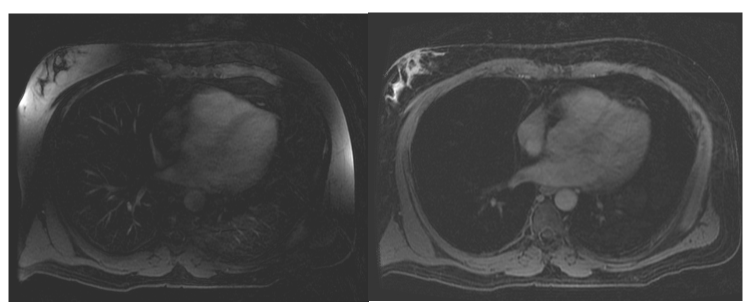

**Figure 2.** 51 year-old male with alcoholic cirrhosis and gynecomastia. Comparison of LAVA (left) and MEDAL water-only images (right) reveals superior fat-suppression of the MEDAL sequence.

**Discussion:** Dynamic contrast-enhanced 3D MR imaging of the abdomen and pelvis requires that uniform fat-suppression be reproducible, reliable, and rapid. MEDAL techniques can consistently achieve robust water-only images which do not depend upon magnetic field homogeneity for fat suppression and yield higher SNR per unit time due to the deployment of longer TR as well as the effective 2-NEX acquisition. MEDAL sequences also have the additional benefit of acquiring in/out-of-phase images within a single breath-hold. By alleviating the need to acquire both multiplanar SPGR in/out-of phase and T1-weighted fat-suppressed 3D spoiled gradient echo sequences this can provide a significant reduction in average scan times. Such techniques may be of clinical benefit, particularly in critically-ill patients, where scan times need to be minimized.

**References:**

1. Ma, J., et al. Fat-Suppressed Three-Dimensional Dual Echo Dixon Technique for Contrast Agent Enhanced MRI, JMRI, 23:36-41, 2006
2. Ma, J., et al. Breath-hold Water and Fat Imaging Using a Dual-Echo Two-Point Dixon Technique With an Efficient and Robust Phase-Correction Algorithm. MRM, 52:415-419, 2004.