Contrast agent enhanced breast imaging with a combined 3D dual echo Dixon and parallel imaging technique

J. Ma[1], A. T. Vu[2], J. Son[1,3], Y. Liu[1,3], A. Knowles[2], J. Polzin[2], C. Lehman[4]

[1]Imaging Physics, University of Texas M. D. Anderson Cancer Center, Houston, TX, United States, [2]GE Healthcare Technologies, Waukesha, WI, United States, [3]Electrical Engineering, Texas A & M University, College Station, TX, United States, [4]General Oncology & Hematology, Seattle Cancer Care Alliance, Seattle, WA, United States

Introduction

Fat-suppressed 3D gradient echo imaging allows for fast acquisition of high-resolution T1-weighted images. When used with intravenous injection of a paramagnetic contrast agent, this technique can be used to capture contrast enhancement patterns, and thus extremely valuable for detection and characterization of lesions such as in the abdomen or breast [1]. The existing implementation of fat suppression (FS) with the chemical shift selective saturation (CHESS) or the spectral inversion at lipids (SPECIAL), however, is inherently limited by the magnetic field inhomogeneity. Further, because of the scan time constraints, the FS pulses are usually applied only during the repetition times (TR) that correspond to the central phase-encode lines, thus resulting in incomplete FS even when the magnetic field is perfectly homogeneous [2].

Using a robust Dixon phase correction algorithm, previous studies have shown that reliable water and fat separation can be achieved with dual echoes acquired after one excitation when water and fat signals are in-phase (IP) and opposed-phase (OP), respectively [2-3]. This dual echo Dixon technique overcomes the aforementioned fundamental limitations for the existing FS techniques and its scan time is practically equivalent to that by the regular 3D gradient echo technique with conventional FS. In this work, we combine the dual echo Dixon 3D fast gradient echo technique with parallel imaging [4] to further reduce the scan time, and demonstrate that high quality contrast enhanced images can be reliably achieved in a clinical setting.

Methods

A product fast 3D gradient echo pulse sequence (GE Healthcare Technologies, Waukesha, WI) was modified by adding a second echo acquisition with a readout gradient of opposite polarity immediately after the first echo. With an appropriate receiver bandwidth after the frequency encoding steps have been selected, the two echo times were placed automatically by the pulse sequence program at approximately 2.3 and 4.6ms, respectively. The Dixon image processing algorithm and its combination with parallel imaging, described in detail in References [3] and [5], were implemented as a host image reconstruction program: after data acquisition, the program is triggered automatically, generates separate water-only and fat-only images for each slice, and installs the images into the scanner's DICOM compatible database.

As part of a multi-hospital evaluation of the technique, axial patient bilateral breast images were collected on a 1.5 Tesla scanner with an 8-channel phased array breast coil at a clinical hospital. Parallel imaging acquisition was performed using ASSET (array spatial sensitivity encoding technique) with an acceleration factor of 2. The coil sensitivity profiles, which were used for all the ASSET acquisitions in the exam, were determined in a separate low-resolution acquisition. Other imaging parameters for the Dixon acquisition were as follows: TR = 7.3ms, FOV = 35x35cm, acquisition matrix = 512x350x64, slice thickness = 2.2mm (interpolated to 1.1mm), flip angle = 12^o, receiver bandwidth = ±100 kHz, 70% partial kz, and total acquisition time per series = 58 seconds. For comparison, a regular 3D fast gradient echo with SPECIAL for FS and ASSET parallel imaging was used to acquire images of the same patient with identical scan parameters and within the same total scan time. Both sets of the images were acquired post intravenous injection of gadolinium contrast agent.

Results

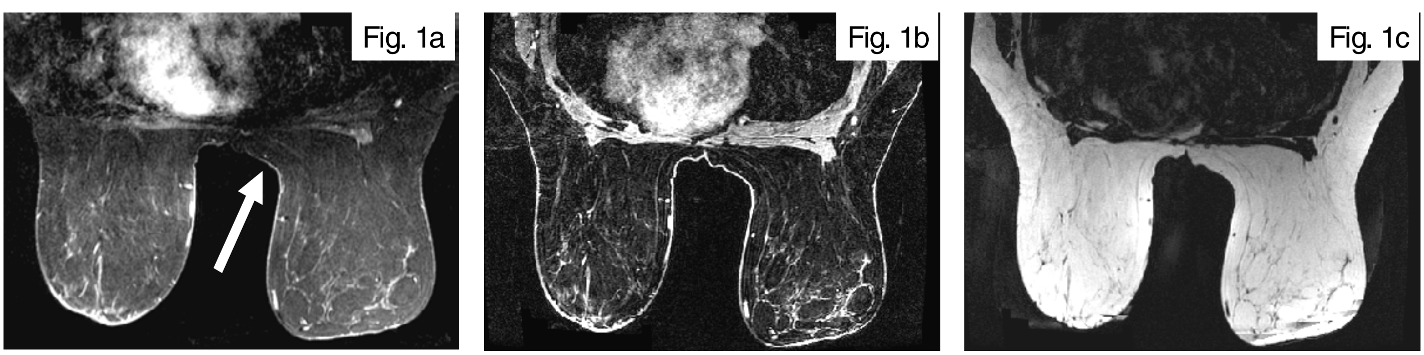

Fig. 1a) shows the image of a representative slice by the regular 3D fast gradient echo with SPECIAL for FS and ASSET. Due to the large field-of-view (FOV) used, uneven FS is apparent in many parts of the image, particularly around the chest wall (e.g., areas indicated by the arrow). In comparison, Fig. 1b and 1c show the water-only and the fat-only image of the same slice by the dual echo Dixon technique with ASSET. The Dixon water-only image shows clearly better SNR and more uniform FS throughout the FOV, which are consistent with the findings when no ASSET is used [2]. Finally, the Dixon water-only image does not suffer from the residual fat within the breast parenchyma as in Fig. 1a), a difference that we attribute to the partial application of the FS pulses in the conventional technique.

Conclusions

For the same scan parameters, the combined dual echo Dixon 3D fast gradient echo and parallel imaging technique achieves the same imaging speed as the conventional 3D gradient echo with FS and parallel imaging. Our experiment demonstrates that the Dixon technique offers better SNR, more consistent and uniform FS, and does not suffer from the presence of residual fat as seen in the images obtained with the conventional FS. We therefore conclude that the Dixon technique is a superior and practical alternative for 3D imaging of contrast agent enhancement.

References

[1] Rofsky NM, et. al., Radiology, 1999; 212:876-884. [2] Ma J, et. al., JMRI, 2005 (in press). [3] Ma, J, MRM, 2004; 52(2):415-9. [4] Pruessmann KP, et. al. MRM, 1999; 42:952-962. [5] Ma J, et. al., MRI, 2005 (in press).