Coil-by-Coil vs. Direct Virtual Coil (DVC) Parallel Imaging Reconstruction: An Image Quality Comparison for Contrast-Enhanced Liver Imaging

P. J. Beatty[1], J. H. Holmes[2], S. Chang[3], E. Bayram[3], J. H. Brittain[4], and S. B. Reeder[5]

[1]Applied Science Laboratory, GE Healthcare, Menlo Park, CA, United States, [2]Applied Science Laboratory, GE Healthcare, Waukesha, WI, United States, [3]GE Healthcare, Waukesha, WI, United States, [4]Applied Science Laboratory, GE Healthcare, Madison, WI, United States, [5]Departments of Radiology and Medical Physics, University of Wisconsin-Madison, Madison, WI, United States

Introduction High channel count parallel imaging arrays enable an increase in net parallel imaging acceleration that can be used to increase coverage, improve spatial resolution and/or reduce acquisition time. One of the challenges of high channel count arrays, especially for multi-phase and/or multi-echo acquisitions, is the increase in computation time and memory that is required to process the high channel count data. Direct Virtual Coil (DVC) parallel imaging [1,2] addresses this challenge by directly synthesizing unaccelerated data for a virtual coil from accelerated data acquired by multiple source coils. For high channel count arrays, this approach is much more efficient than coil-by-coil methods [3,4]. In this study, we compare the image quality of the DVC reconstruction technique to the coil-by-coil approach in the context of multi-phase contrast enhanced liver exams. Our results confirm that the DVC approach achieves nearly identical image quality to the coil-by-coil reconstructions in the cases examined, while significantly reducing the computational burden of the reconstruction.

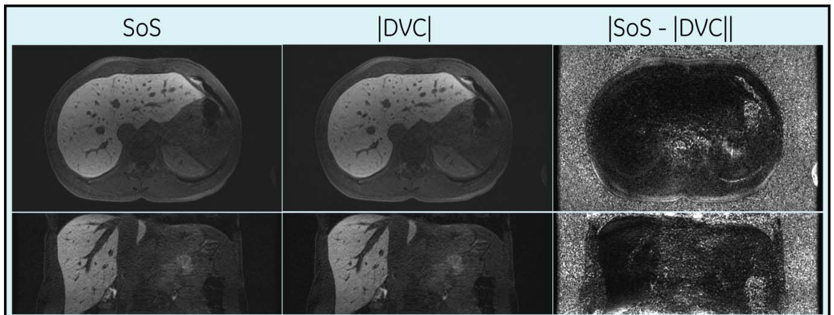

Figure 1 Selected imaging results for one of the cases in this study, showing an axial plane and a reformatted coronal plane from the same 3-D dataset. The left column shows the results of a coil-by-coil reconstruction with root sum-of-squares reconstruction. The middle column shows the direct virtual coil (DVC) reconstruction results. The right column shows difference images, brightened to show differences between reconstructions. Note that the bulk of the difference energy is in the background noise, which appears black in the reconstructed images.

Methods All imaging was performed on a clinical 3T scanner (MR 750, v20.0, GE Healthcare, Waukesha, WI) using the 20 superior elements of a 32-channel body phased array (Neocoil, Pewaukee, WI). Data from five representative patient volunteers were collected and reconstructed offline using both DVC and coil-by-coil approaches. Both reconstructions used ARC [5,6] for parallel imaging calibration and data synthesis.

The DVC reconstruction included an extra step before data synthesis to merge the parallel imaging calibration with the results of a channel combination calibration. Since the main purpose of the DVC approach is to reduce the number of multiply/add operations that form the bulk of the data synthesis computation, the reconstructions were modified to record the number of these operations for both reconstruction approaches.

For each case, 3-D gradient echo acquisitions were acquired in the axial plane at 5-minute intervals after contrast injection. All acquisitions contained internal calibration data, with an outer parallel imaging acceleration factor of 3x2. The acquired matrix size was 288x224x100 with 22s scan time. For each case the temporal phase nearest to peak contrast in the biliary system was interpreted by a board certified radiologist and scored in three categories, each with a score on a 0-3 scale: Overall image quality (0= non-diagnostic , 1=poor, 2= clinically adequate, 3=excellent), SNR (0= non-diagnostic , 1=poor, 2=clinically adequate, 3=excellent), and artifacts (0=non-diagnostic , 1=diagnostic but with strong artifacts, 2=diagnostic with minor artifacts, 3=diagnostic with good image quality and minimal/no artifacts). Radiologist comments were also recorded.

Results For the protocol used in this study, the DVC reconstruction reduced the multiply/add operations used to synthesize unacquired data by a factor of 5.4X, compared to the coil-by-coil reconstruction. Representative image results are shown in Fig. 1 and radiologist scoring is shown in Fig. 2. In all cases, the DVC reconstructions scored identically to the coil-by-coil reconstructions. In four of the five cases, the radiologist comments stated that the DVC and coil-by-coil image sets appeared identical while for one image set, very subtle differences on the last slice of the volume due to wrap artifact were noted.

Discussion This study presents the first radiologist-evaluated image quality comparison between coil-by-coil parallel imaging reconstructions and the direct virtual coil reconstruction approach. For the cases examined in this study, the DVC reconstructions were determined to be nearly identical to the coil-by-coil reconstructions. These preliminary results are promising, because the DVC method aims to achieve similar image quality to coil-by-coil reconstructions while achieving markedly increased computational efficiency and reducing memory requirements. Additional clinical studies are on-going to further test DVC image quality.

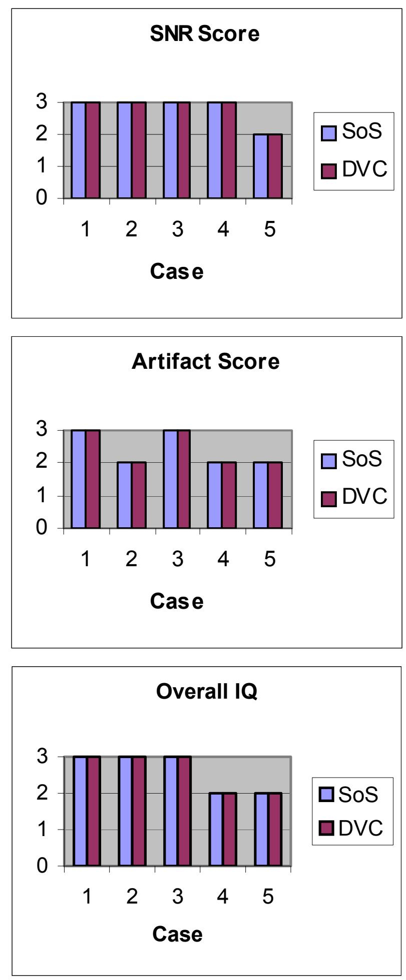

Figure 2 Radiologist scoring SoS = coil-by-coil reconstruction with root sum-of-squares coil combination.

References [1] Beatty et al., ISMRM 2008, p8. [2] Beatty et al., ISMRM 2009, p2727. [3] McKenzie et al., 2001, MRM 46:619-23. [4] Griswold et al. 2002, MRM 47:1202-10. [5] Brau et al., MRM 2008; 59:382. [6] Beatty et al. ISMRM 2007, p1749.