Comparative evaluation of conventional and "diamond" SENSE

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Introduction:

Recently new methods to improve image quality in parallel 3D imaging by modifying the k-space sampling have been proposed [1, 2]. Shifting the sampling positions as described in [1,2] modifies the aliasing pattern in a way that generally improves the geometry factor of the image reconstruction. However, it has been shown that the specific behavior, and therefore the specific improvement, of the geometry factor depends on the chosen acceleration factor in each of the encoding directions and on the position of the imaging volume with respect to the coil [3]. In this paper we evaluate the performance of parallel imaging using the new diamond sampling pattern and compare it to the performance of conventional 2D SENSE [4] for two specific clinical applications.

Methods:

The diamond and conventional sampling patterns were implemented on a GE 1.5T Signa Twinspeed system (GE Healthcare Technologies, Milwaukee, WI). The reconstruction was performed on-line using the EXCITE vector array processors with 2GB of memory. We implemented the shift in the k-space sampling proposed in [1, 2] in the slice encoding direction since the applications we selected typically have a smaller FOV in the slice direction than in the phase direction and therefore stand to benefit more from a diamond sampling pattern implemented in that direction. An 8-element phased-array cardiac coil was used for the acquisition of the liver images, and a 4-element phased array breast coil was used for the acquisition of the breast images. In each case, an acquisition using the diamond sampling pattern was immediately followed by an acquisition using conventional 2D SENSE. The imaging parameters and the locations for each set of scans were identical for both acquisitions. No contrast was used in either acquisition. The images were compared visually, and the geometry factor of each reconstruction was calculated.

Following informed consent, healthy volunteers were placed in the scanner for each of the applications. The liver acquisition was a 60 slice, 3D spoiled gradient echo axial scan with a 12° flip angle, 32 cm FOV, 4.9 ms TR, 1.2 ms TE and 3 mm slice thickness. The phase encode direction was placed A/P with an acceleration factor of 2 and the slice encode direction was placed in the S/I direction with an acceleration factor of 2. The breast acquisition was a 92 slice, 3D spoiled gradient echo sagittal scan with a 10° flip angle, 30 cm FOV, 7.7 ms TR, 3.5 ms TE and a 2 mm slice thickness. The slice encode direction was R/L with an acceleration factor of 2. The phase encode direction was A/P with no acceleration.

Results:

Figures 1 and 2 show representative slices of the liver and breast, respectively. Section A of each figure was acquired using the diamond sampling pattern, and section B was acquired using a conventional sampling pattern. Arrows indicate sections of the images where the use of a diamond sampling pattern allowed the reconstruction algorithm to resolve the aliasing but the use of a conventional sampling pattern did not. The liver images showed a noticeable reduction in artifacts when diamond sampling was used, whereas the breast images were comparable for the two cases.

Discussion and Conclusion:

The use of diamond sampling in 3D parallel imaging produces equal or better results than conventional sampling in the clinical applications we studied. Applications in which the slice field of view is thin seem to benefit the most from the change in the sampling pattern. There also seems to be an important benefit in situations in which the acceleration factor in any given direction approaches the number of coils in that direction. The increased robustness in the reconstruction when using a diamond sampling pattern may allow the use of higher acceleration factors.

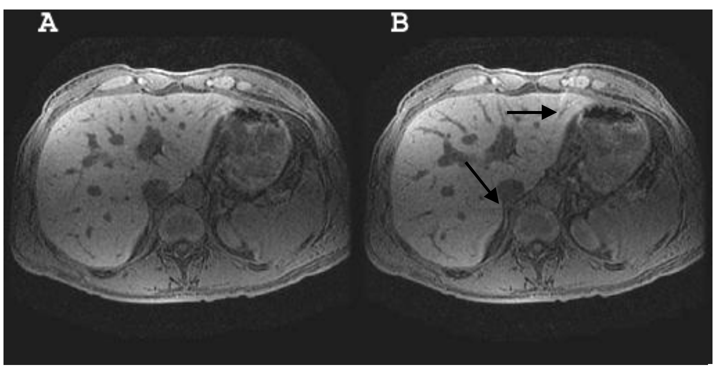

Figure 1. Representative slices of a liver volume. Section A was acquired using diamond sampling. Section B was acquired using conventional 2D SENSE sampling. An acceleration factor of 2x2 was used in both acquisitions. Arrows indicate sections of the image where reconstruction using conventional sampling could not resolve the aliasing. The average geometry factor for the presented slices was 1.2 and 1.6, respectively.

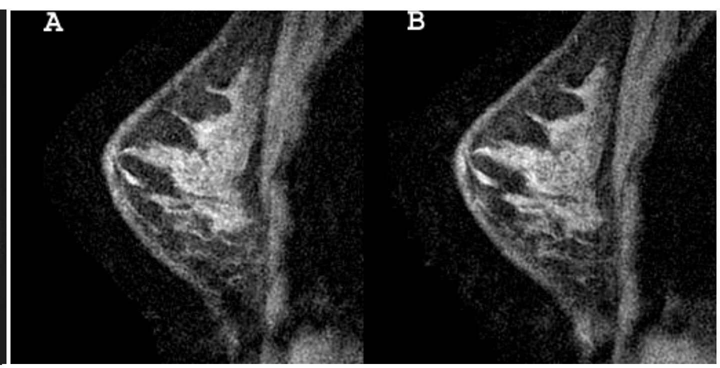

Figure 2. Representative slices of a breast volume. Section A was acquired using diamond sampling. Section B was acquired using conventional 2D SENSE sampling. An acceleration factor of 2 was used in the slice encode direction for both acquisitions. Image quality for both reconstructions is comparable. The average geometry factor for the presented slices was 1.5 for both cases.

References:

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2. Jurissen, M et al. ISMRM 2004, 2643
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4. Weiger M, et al. MAGMA 2002;14;10