# Accelerated Bilateral DCE 3D Spiral Breast Imaging: Comparison between TSENSE and TGRAPPA

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**Introduction:** By combining a dual-band spectral-spatial pulse [1] with phase modulation [2] and 3D spiral imaging [3], both breast volumes can be efficiently imaged with excellent fat suppression. For dynamic contrast enhanced (DCE) breast MRI, temporal resolution can be increased through a time-interleaved acquisition of phase-encode planes, followed by a parallel imaging reconstruction such as TSENSE [4] or TGRAPPA [5]. With a time-interleaved acquisition, coil sensitivity maps for SENSE or coil weight coefficients for GRAPPA can be estimated from the acquired data without the need for an extra calibration scan. We have compared the combination of 3D spiral imaging with TSENSE and TGRAPPA in bilateral DCE breast MRI.

**Methods:** Imaging was conducted with a GE 1.5T Excite scanner and either an eight channel phased-array breast coil (GE Healthcare, Milwaukee, WI) or a seven channel phased-array coil (Invivo Corp, Waukesha, WI). Both breasts were excited simultaneously using a dual-band spectral-spatial pulse that incorporated phase modulation in order not to image the region between the breasts. All scans used a "stack-of-spirals" imaging trajectory with 9 spiral interleaves constituting a phase-encode plane. Additional sequence parameters included a 40º flip angle, a 20 x 20 cm FOV (in-plane), 1.05 mm x 1.05 mm resolution, 3.6 mm slice thickness and 32 sagittal 3D sections over each breast volume. With an acceleration factor of two in the slice direction, phase-encode planes were acquired in a time-interleaved manner (Fig. 1), alternating between even and odd planes. With a 31 ms repetition time (TR), the scan time for a temporal frame (half of the phase encode planes) was 10s and Gd-DTPA was injected after the 4$^{th}$ temporal frame. A total of 20 temporal frames were acquired over 200 s to capture contrast dynamics for the wash-in period.

Both TSENSE and TGRAPPA reconstructions were applied to bilateral MRI exams from 15 patients with tumors. Informed consent was obtained from all the patients. After 2D gridding and linear off-resonance correction for each sagittal plane, SENSE and GRAPPA reconstruction were applied in the slice direction. A full k-space reference data set for reconstructing the frames before the contrast injection was acquired by averaging the four pre-contrast frames. For reconstructing the post-contrast frames the reference data were acquired by averaging the last ten post-contrast frames in order to avoid the rapid signal change immediately following the injection. For the SENSE reconstruction, full k-space coil images were normalized by the square-root sum-of-squared magnitudes and used as sensitivity maps. For the GRAPPA reconstruction, the reference data set was used as a complete set of auto-calibration signal lines to estimate coil weight coefficients. No regularization was used for SENSE and GRAPPA.

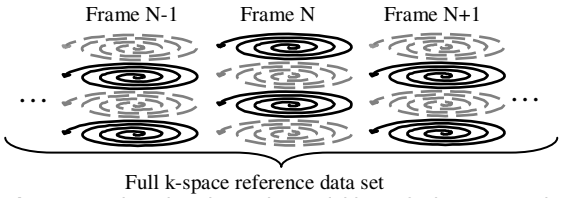


**Figure 1.** Time interleaved acquisition of phase encode planes with an acceleration factor of two. By combining several adjacent temporal frames, full resolution reference data set can be acquired.

**Results**: Figure 2 shows two bilateral unfolded sagittal slices from the TSENSE (a-b) and TGRAPPA (d-e) reconstructions. Signal intensity curves from the reconstructed images were measured in two ROIs from a tumor identified as an invasive ductal carcinoma. The signal intensity curves from the unaccelerated images are plotted as well. The increase in temporal resolution made possible by the acceleration is noticeable by the increased enhancement rate. TGRAPPA yields less oscillation in the signal intensity curves, due to fewer residual aliasing artifacts. Figure 3 shows a sagittal TGRAPPA reconstructed image from another patient with an infiltrating lobular carcinoma, as well as axial reformatted views from 3D TSENSE and TGRAPPA reconstructions. Aliasing artifacts from TSENSE can be seen inside the chest wall because of errors in sensitivity estimates. These artifacts were not visible in the GRAPPA reformatted slice. When comparing the signal intensity curves from the tumor, TGRAPPA again yields less oscillation than TSENSE.

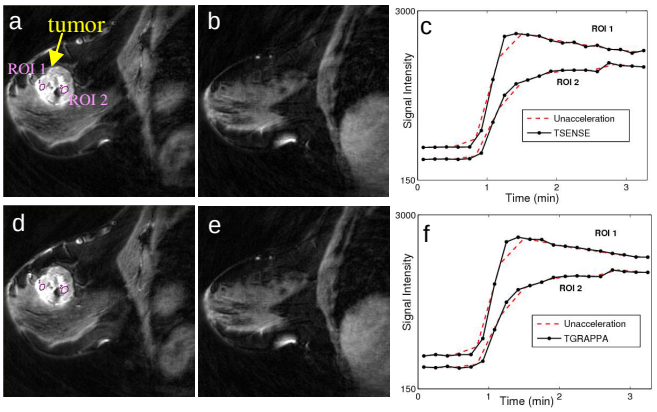


**Figure 2.** Post-contrast bilateral breast images. (a-b) Two unwrapped slices using TSENSE from the left breast (a) and the right breast. (c) Signal intensity curves measured in two ROIs located in the tumor. (d-e) Two unwrapped slices using TGRPAPA. Signal intensity curves were shown in (f). Curves from the unaccelerated images were also plotted in (c) and (f).

**Discussion:** Both TSENSE and TGRAPPA reconstructions can provide diagnostic 3D spiral DCE bilateral breast images with 10s temporal resolution. In general, TGRAPPA provided less oscillation in DCE curves of the tumors from the 15 patients. For TSENSE, correct sensitivity-value estimation from dynamic images is sometimes challenging due to low signal regions from fat-suppression, signal intensity changes over time and spiral motion artifacts. These issues can all result in residual aliasing artifacts. In contrast, local errors in the TGRAPPA reference images produce a slight noise enhancement over the entire FOV. Further investigation is needed to establish whether or not this may affect the quantification of enhancement curves from tumors.

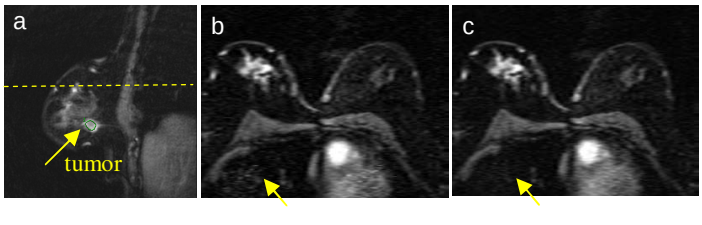


**Figure 3.** (a) A sagittal slice reconstructed using TGRAPPA from a second patient. (b-c) Axial reformatted slices from TSENSE (b) and TGRAPPA (c) corresponding to the dashed line in (a). (d) Signal intensity curves from the ROI in the slice (a) from unacceleration, TSENSE and TGRAPPA. The yellow arrow in (b) indicates aliasing artifacts that are not present in (c).

**References**

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