Evaluation of Multi-Coil Breast Arrays for Parallel Imaging

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Introduction: Parallel imaging methods such as SENSE[1] enable accelerated image acquisition while maintaining spatial resolution, and are used increasingly for dynamic contrast enhanced (DCE) breast MRI. The achievable signal to noise ratio (SNR) and parallel imaging performance for a given imaging sequence are strongly dependent on the radio-frequency coil array used to acquire the data. In this study two commercially available 8 element coils and a prototype 16 element coil were compared. Their performance for both conventional and SENSE-accelerated imaging was assessed in terms of SNR, g-factor and uniformity.

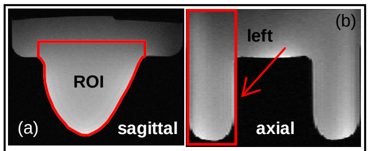

Fig 1: (a) ROI, central slice of left breast, (b) the left breast slices fig 5 & tables refer to

Methods: A breast phantom was manufactured with dimensions representing the average measurements of a sample of breast images. A chest wall component was included to simulate the thermal noise introduced by the body. Scans of the phantom were performed using three breast coil arrays; (1) GE 8 element high density breast coil (GE8), which has coils in a fixed arrangement within the coil housing, (2) Sentinelle Medical 8 element Vanguard breast MR auxiliary table (SM8), which has coils embedded in adjustable lateral plates that gently compress the breast tissue during scanning, and (3) Sentinelle Medical 16 element prototype coil (SM16) with adjustable lateral plates. Experiments were conducted using a GE 1.5T Signa Infinity system and data were processed in Matlab. Sagittal images (FOV: 24x24x22.5cm, matrix: 256x256x90) were acquired using a 3D spoiled gradient echo (SPGR) sequence (TR/TE/θ = 7.5ms/4.2ms/15^o). Coil sensitivity data (matrix: 64x64x90) and noise samples (2DSPGR, matrix: 256x256) for SNR calculation were acquired prior to image data. The image data was subsampled by factors (R) of 2 and 3 in the left-right (LR) direction (k_z), 2 and 3 in the superior-inferior (SI) direction (k_y), and a combination of 2 LR and 2 SI (R=4 total). Subsampled data were reconstructed using SENSE, and fully sampled data were reconstructed by root sum of squares (RSS) combination. SNR-scaled images[2,3,4] and g-factor maps[1] and were calculated and compared between coils for the different acceleration factors. Uniformity (mean divided by standard deviation of the RSS image), average SNR, average of the g-factor over the accelerated area ('mean accelerated g-factor') and the maximum g-factor were calculated slice by slice for a region of interest (ROI) including the breast compartment and part of the chest wall behind (fig 1a).

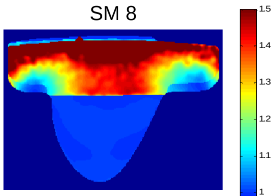

Fig 4: G-factor map for R=3 LR SENSE, medial slice (slice 24)

Results: SNR-scaled images (fig 2) and g-factor maps (fig 3) are shown for a medial slice (where there is R=2 aliasing in the breast compartment) with R=2 LR acceleration, imaged using coils (a) SE8, (b) GE8 and (c) SE16. The g-factor map for the same slice with R=3 LR SENSE imaged using the SM8 coil is shown in figure 4 (c.f. fig 3(a)). Figure 5 compares the three coils' (a) uniformity, (b) RSS average SNR and (c) mean accelerated g-factor for R=2 LR SENSE. Table 1 shows the mean and standard deviation SNR, and table 2 the mean accelerated and maximum g-factor, for the three coils at different accelerations. These values and the plots in fig. 5 are for the regions of interest in the left breast shown in fig 1.

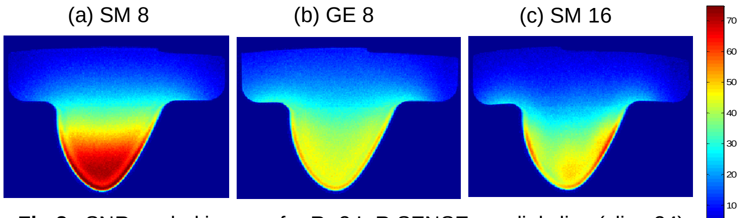

Fig 2: SNR-scaled images for R=2 L-R SENSE, medial slice (slice 24)

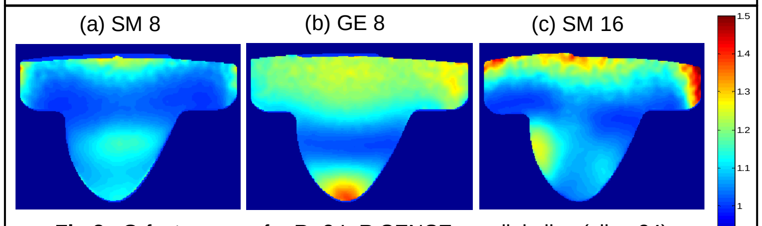

Fig 3: G-factor maps for R=2 L-R SENSE, medial slice (slice 24)

Discussion and Conclusions: The SM8 coil had the highest intrinsic SNR. The peak average SNR of the GE8 and SM16 coils were approximately 75% and 50% lower respectively than the SM8 coil (fig 5b). This SNR relationship between the three coils held for all the accelerations tested. The signal uniformity of the GE8 coil was superior to that of the SM coils. The 16 channel coil produced low g-factors for accelerations in both LR and SI, and R = 4 SI-LR g-factors comparable to R = 3. The 8 channel coils performed well in the LR direction, but did not have the capability for acceleration in the SI direction across the whole volume. In LR SENSE, there were some slices where the g-factor within the breast compartment was lower for R=3 than R=2 due to the pattern of aliasing for breasts (c.f. figs 3(a) and 4). The extent of this effect will depend on the breast geometry. Locating the adjustable coils next to breast tissue (SM8) provided a marked increase in SNR over a fixed coil arrangement (GE8), but the image uniformity suffered as a consequence. The unexpectedly low SNR of the prototype SM 16 coil is likely due to coupling between coil elements, which was much higher than for either 8 channel coil. However, as this is an early prototype coil, we expect to see substantial improvements with further development.

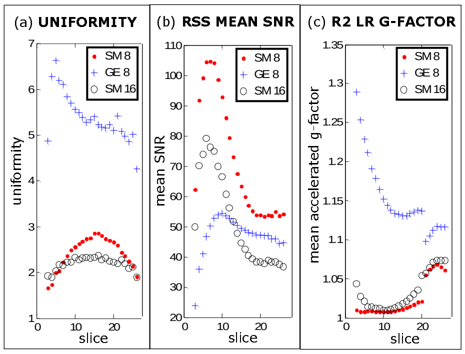

Fig 5: (a) uniformity, (b) RSS mean SNR and (c) R=2 LR SENSE average accelerated g-factor as a function of slice, for the ROIs in the left breast (see fig. 1)

Coil	RSS	R2 LR	R3 LR	R2 SI	R3 SI	R4 LR-SI
SM 8	73	53	43	53	42	37
GE 8	47	35	27	32	22	23
SM 16	53	38	32	38	30	27

Table 1: mean SNR for ROIs in the left breast

Coil	R2 LR	R3 LR	R2 SI	R3 SI	R4 LR-SI
SM 8	1.03 / 1.21	1.07 / 1.73	1.06 / 1.64	1.22 / 3.23	1.08 / 1.97
GE 8	1.14 / 1.42	1.28 / 2.36	2.34 / 4.37	2.67 / 10.91	2.01 / 7.26
SM 16	1.04 / 1.33	1.07 / 1.83	1.01 / 1.30	1.05 / 2.14	1.06 / 1.55

Table 2: mean accelerated / maximum g-factor for ROIs

Acknowledgements: Thanks to Ryan Fobel for useful discussions, and to the Terry Fox Foundation for research grant support.

References: (1) Pruessmann KP et al, Magn. Reson. Med. 1999;42:952-962; (2) Erdogmus D et al, Signal Processing 2004;84:997-1003; (3) Kellman P et al, Magn. Reson. Med. 2005;54(6):1439-47; (4) King SB et al, Concepts Magn. Reson. 2006;29B:42-49.