High Resolution 3T MR Mammography with Higher R- Factors

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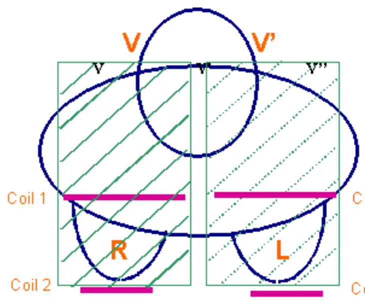
Introduction

For women who are at high risk of developing breast cancer due to a genetic predisposition or previous history, MRI is emerging as a powerful tool. However, breast imaging provides many challenges for MR. Breast imaging requirements include a need to enhance lesions relative to normal breast parenchyma. There is a need to assess morphological features of the complete breast such as spiculated edges and rim enhancement. This requires relatively high resolution in both in-plane and through plane resolution for entire breast coverage. Optimally, these requirements must be completed bilaterally, for a comparison of uptake of contrast agent between both breasts. The use of dynamic contrast enhancement kinetics has increased specificity, however there are tradeoffs between the temporal and spatial resolution. This abstract discusses the use of a 3T MR system, the coil specifically designed for this function and the use of parallel imaging to acquire higher resolution imaging in the sagittal plane.

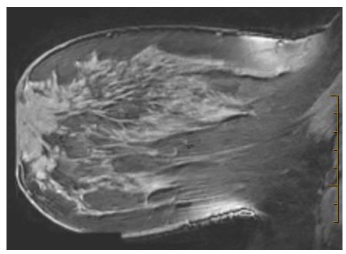
Methods

Images were collected on a 3T GE system, using 3D gradient echo technique with flip angle of 10 degrees, a matrix of 256 x256, a slice thickness of 2.0 mm and bandwidth of 62.5 kHz. The number of slices was between 80 and up to 128 slices on large breasted patients to allow for imaging within the nodal region. The FOV was dependent on the patient's breast size between 14 cm and 22 cm. Fat suppression was accomplished using a spectrally selective inversion pulse at the resonant frequency of fat, with inversion time of the pulse set to minimum. Multiple lines of k-space were collected for a single inversion pulse to decrease acquisition time. All studies were run under an IRB protocol.



A prototype coil was designed for the slice oriented parallel imaging. The coil was specifically designed to accommodate various sizes. The bottom coils can be turned off for small breasts, and the coil is built to accommodate very large habitus. The underlapped design, as shown in Figure 1, allows for greater flexibility and optimization with the use of parallel imaging. For breast imaging, we have been using parallel imaging in the slice direction with sagittal imaging to provide optimal scan efficiency. The scan time decrease comes from under sampling k-space in the slice direction. The full prescribed slab is excited, but slice encoding is played out for a slab that is R times thinner so there is aliasing from signal outside the relatively thin encoded slab. Aliasing is eliminated using receive coil sensitivities to combine the multi-coil aliased images in a way that cancels the aliasing. At 3T, the SNR is much higher so it is possible to use higher factors of undersampling (R factors). R-factors between 2 and 4 have been tested.

Figure 2a – 2X Sagittal Breast



Results

The 3D gradient echo technique provides good general image quality including fat suppression with adequate temporal resolution for dynamic imaging. The use of parallel imaging has provided additional resolution with minimal increase in artifacts associated with the un-wrapping of data as shown in Figure 2 a&b. For parallel imaging, the SNR of accelerated imaging is given by $SNR = SNR_0 / g\sqrt{R}$, where R is the acceleration factor and SNR_0 is non-parallel imaging SNR. The coil produced theoretical mean g-factors of 1.02 for a spherical phantom and 1.00 for cylindrical phantom, peak g-factors were 1.04 and 1.14 respectively for a sagittal slice. Therefore, the SNR will be dependent on $1/\sqrt{R}$ and is not limited by the g-factor. At R=4, g-factor becomes more predominant and foldover adds additional noise to the images. Figure 2a is a slice through the breast pre-contrast with a slice acceleration factor of 2. Figure 2b is the same slice through the same breast pre-contrast with acceleration factor of 3. The difference between the SNR in the two images was less than 15%, much smaller decreases were seen for a 2.5 acceleration factor. The scan time difference between the 2X and 3X was 45 seconds. The additional SNR provided by the 3T system, can be used to increase resolution or decrease scan time and is not limited by the coil geometry but rather by fewer data points acquired.

R	2	2.5	3	4
SNR	1.0	.91 ± .08	.84 ± .05	.63 ± .13
CNR	1.0	.89 ± .12	.82 ± .14	.56 ± .15

Figure 2b – 3X Sagittal Breast

Patient images show good detail of the breast including the suspensory ligaments, lactiferous duct, gland lobules, and pectoral muscle. A small amount of foldover artifact can be seen in the posterior region of the 3x image.

Discussion

As with most MR techniques, there are trade-offs between spatial resolution and acquisition time. Parallel imaging on the 3T, uses the additional signal afforded by the higher field strength, to accelerate the scan time. The amount of acceleration possible is not limited by the coil geometry in the case of 2X and 3X acceleration but rather by the limited amount of data that is acquired. Improvements on the coil, may lead to additional SNR improvements at 4X. The use of slice oriented parallel imaging allows the true simultaneous acquisition of high-resolution sagittal images from both left and right breasts. Each line of data is acquired from the left and right breasts simultaneously, with only minimal increase of acquisition time relative to a unilateral exam with equal spatial resolution. The technique allows for acquisition of both the left and right breasts with excellent fat suppression in 1-2 minutes. The 3T system provides good contrast to noise in the images as well as the possibility to increase specificity through the use of spectroscopy at the higher field strength.