IN VIVO 3D SINGLE/TRIPLE QUANTUM SODIUM MRI OF THE HUMAN BREAST

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SYNOPSIS

We demonstrate the feasibility of performing triple quantum filtered sodium MRI in the breast of female normal human volunteers at 3.0T using a 17cm diameter distributed capacitance transmit/receive surface coil. Our results indicate that 3D images of adequate signal-to-noise ratio and spatial resolution (>1cc) can be acquired in acceptable imaging times (<16mins).

PROBLEM

Breast cancer is the most common form of cancer among woman. Although there is not known cure to breast cancer, it is generally well accepted that early detection is crucial for improved therapeutic outcome. While mammography has shown to be an effective means of breast cancer detection, it is not 100% accurate, and it averages a 90% detection rate of breast cancer in women without symptoms. Contrast enhanced MRI has proven to be very sensitive, but it is non-specific [1]. Clearly, a non-invasive technique that could be used to improve the characterization of breast neoplasms could prove very useful for the diagnosis and staging of breast cancers. Because of its important role in cell physiology, the sodium ion is sensitive to the metabolic changes that accompany many tissue pathologies. In particular, it has been shown that the intracellular concentration of sodium has a positive correlation with proliferative activity in a variety of human neoplasms [2]. In this work we demonstrate the feasibility of performing single and triple quantum sodium MRI in the breast in vivo. We demonstrate that images of adequate SNR and spatial resolution can be obtained in acceptable imaging times using clinical 3.0T MRI scanners.

METHODS

Normal human volunteers (n=4, ages 22-45) were scanned on a General Electric Medical Systems (Milwaukee, WI) Signa 3.0T whole body scanner using a distributed capacitance 17cm diameter surface coil (figure 1). A three-pulse, triple quantum filtered pulse sequence was used to generate the TQ sodium signal (figure 2) and spatially encode it with a twisted projection imaging readout [3].

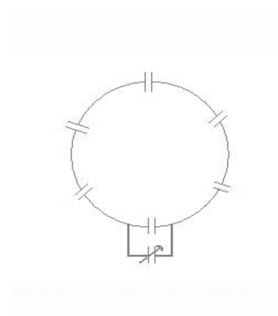

Figure 1. **RF probe**

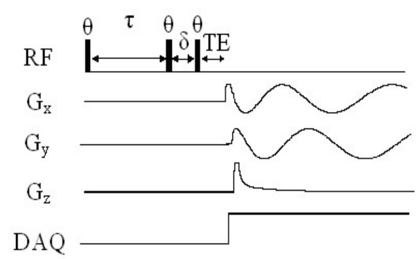

Figure 2. Pulse sequence used for the studies. The phase of the first two RF pulses is stepped each TR through the values: 30^0, 90^0, 150^0, 210^0, 270^0 and 330^0, while the phase of the last pulse is kept constant (zero). The quantities τ and δ are referred to as preparation and evolution time, respectively.

The three-pulse pulse sequence was used in order to minimize the signal loss arising from the B_1 fall-off of the RF coil [4]. The efficiency of the multiple quantum filter was optimized prior TQ sodium MRI by acquiring a TQ sodium FID's (2 minutes, 100 averages) and determining its relaxation properties through a nonlinear fit. All images were reconstructed offline using a SGI Octane workstation (SGI, Mountain View, CA).

RESULTS

The average of the optimal preparation time for the four volunteers was 3.2ms. Figure 2 presents selected partitions from the 3D SQ and TQ sodium images from the right breast of one of the volunteers. In these images, the circular structures at the inferior aspect of the images correspond to calibration standards with know concentrations of sodium (40, 80 and 120mM from left to right) in agarose solution (10%). These standards are used for the determination of the absolute tissue sodium concentration in the single quantum sodium images of figure 3. The SNR and spatial resolution of images are also adequate for the visualization of anatomical structures such as the heart and breast parenchyma.

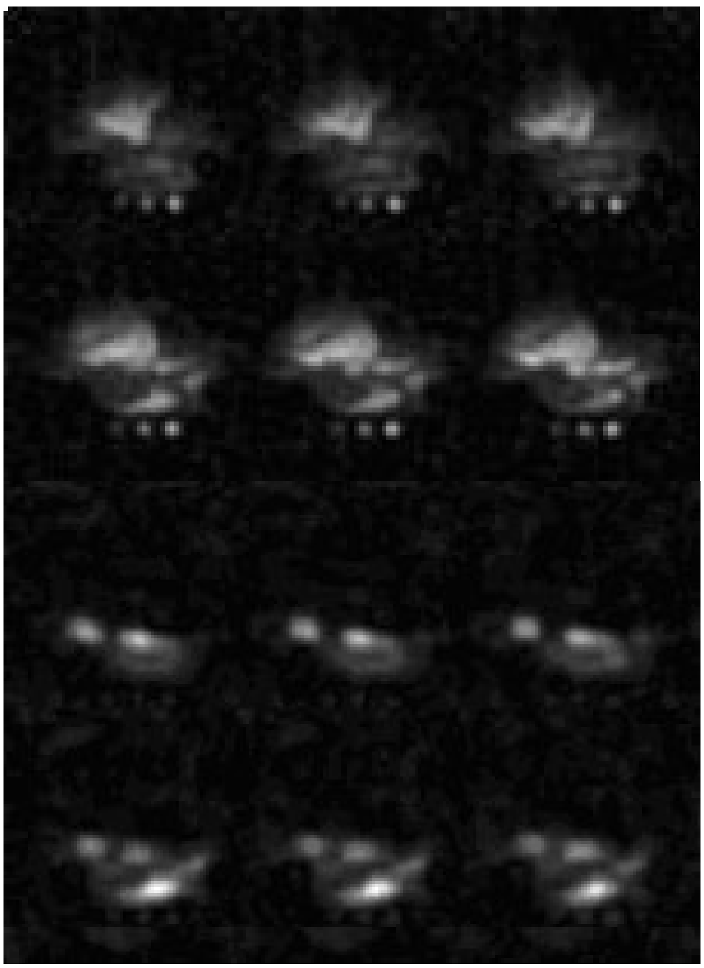

Figure 3. Single (top) and triple (bottom) quantum images from the breast of a normal human volunteer. The images were acquired at 3.0T using a 7in surface coil. The voxel sizes are 0.25cc and 0.5cc for the SQ and TQ images, respectively.

CONCLUSIONS

We have demonstrated that it is feasible to obtain triple quantum sodium images from human breast, in vivo in acceptable imaging times using commercial 3T scanners. Our results demonstrate that the SNR and spatial resolution of the images is adequate for monitoring the TQ sodium signal in most anatomical structures. This technique could have a useful role in the diagnosis and early detection of breast neoplasms.

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