3D Prepolarized MRI with RARE

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Introduction

Prepolarized MRI (PMRI) [1,2] is an inexpensive MRI architecture that uses a mid-field copper wire magnet (B_p) for longitudinal magnetization growth and a low-field magnet (B_0) for spatial encoding and data acquisition, as shown in Fig. 1. This setup offers the SNR of mid-field imaging combined with the benefits of low-field imaging, which include reduced susceptibility shifts, relaxed homogeneity, reduced SAR, and quiet gradients. The magnets, gradients, and RF coils in our 0.4T/52mT PMRI magnet system cost only $25,000 in total. Slice interleaving is inefficient for volumetric imaging in PMRI, so a fast 3D imaging technique, such as RARE [3], is essential to efficient PMRI.

Methods

We implemented RARE in PMRI using special techniques for eliminating artifacts due to transient B_0 field error and concomitant gradient fields. The transient B_0 error caused by ramping B_p was minimized by properly ramping the two magnets to minimize the induced-EMF voltage on the B_0 magnet. We also evaluated two novel methods for compensating the phase of the CPMG echo train in the presence of transient field error. Lastly, we used quadratic nulling [4] to minimize the artifacts due to concomitant gradient fields. The flexibility of RARE allowed us to achieve T_1 and T_2 contrast by changing the order of k-space acquisition within each echo train to modify the effective TE.

Results and Discussion

Our methods for implementing RARE in PMRI were effective and enabled us to achieve clinical resolution and scan times for *in vivo* wrist imaging, as shown in Fig. 2. Figure 3 demonstrates the use of RARE to image with both T_1 and fat-suppressed T_2 contrast. This work demonstrates the ability to perform clinical quality imaging with PMRI, and as we increase our field levels to 1.0T/0.2T, we expect to achieve SNR close to that of a 1.0T conventional MRI scanner. PMRI has great potential for diagnostic imaging near metal in the body due to greatly reduced susceptibility artifacts at low field.

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[2] Carlson J., et. al. SPIE 1992, pp. 22–27.
[3] Hennig J, et. al., MRM 1986, 3:823–833.
[4] Zhou XJ, et. al.,MRM 1998, 40:582–591.

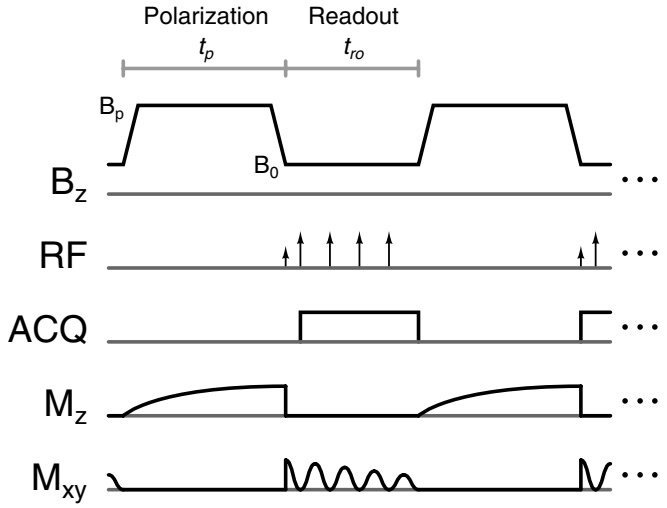
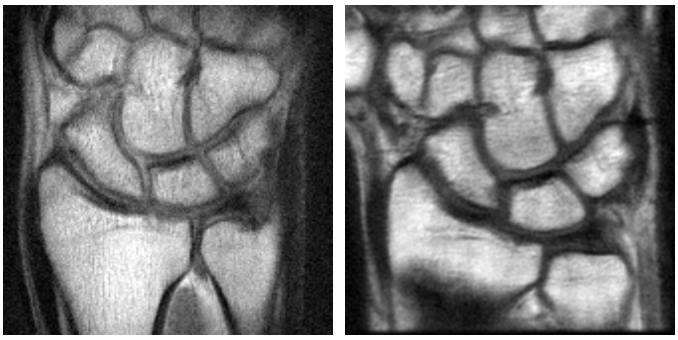
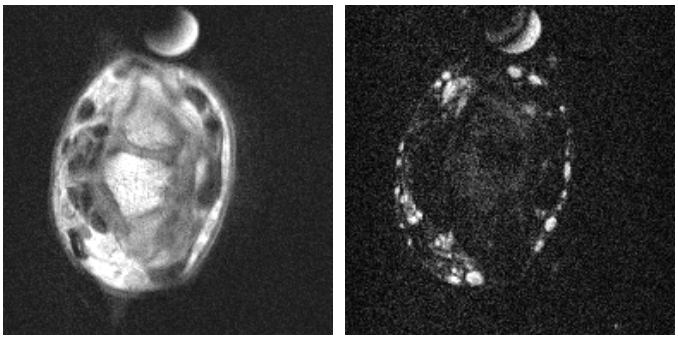


Figure 1: Pulse sequence and magnetization diagrams for echo train imaging with PMRI. M_z growth occurs predominantly during the polarization interval (t_p). In our current system, t_p = 50-1000 ms, t_{ro} = 10-200 ms, B_p = 0.4 T, B_0 = 27-55 mT.



(a) PMRI 0.4T/52mT (b) MRI 1.5 T

Figure 2: Coronal T_1-weighted wrist images from PMRI with 3D RARE at 0.4T/52mT (a) and MRI with 3D FSE at 1.5 T (b) using similar scan parameters. The PMRI image depicts the wrist bones and joint as clearly as the 1.5 T image, but with lower SNR. PMRI scan time = 323 s; 1.5 T scan time = 211 s.



(a) T1 (b) T2 STIR

Figure 3*:* Axial T_1-weighted (a) and STIR fat-suppressed T_2-weighted (b) PMRI with 3D RARE of a healthy wrist and long T_2-doped test tube (top). Ligaments are clearly depicted in (a); and long T_2 species, such as blood, appear bright in (b) while fat signal is suppressed. Scan time = (a) 326 s, (b) 420 s.