Basic Clinical Imaging Techniques in Prepolarized MRI

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Introduction

The goal of prepolarized MRI (PMRI) [1,2,3] is to achieve clinical quality MRI using an inexpensive electromagnet architecture that cycles the main magnetic field between a mid-field level (B_p) for magnetization growth and low-field level (B_0) for spatial encoding and data acquisition. The B_p and B_0 magnets in our PMRI wrist-sized system were custom built for only $25,000 by Stangenes Industries (Palo Alto, CA). Our current hardware provides a B_p field up to 0.4 T and a B_0 field up to 0.2 T. PMRI combines the SNR at mid-field with the advantages of imaging at low-field, such as reduced susceptibility artifact near metal, low SAR, and low acoustic noise.

Methods

We developed our PMRI pulse sequences by adapting the standard MRI methods of slice-selective and 3D volumetric acquisition with GRE, spin-echo, and RARE [4]. For fat suppression, we adapted STIR rather than fat-saturation or Dixon techniques because these are difficult at low field due to the narrow chemical shift. To implement STIR fat suppression in PMRI, the polarizing interval at B_p was followed by an adiabatic inversion pulse at B_0 and an inversion recovery interval at B_p. We achieved T_1-weighting using short polarizing pulses and T_2-weighting using long polarizing pulses and long effective echo times. We imaged several volunteers, who were seated upright with an arm extended into the bore for the short duration of the scan. The scans used typical clinical resolution (0.42mm^2 in-plane, 3mm slice) and scan times (4-7 min.) with B_p = 0.4 T and B_0 = 52 mT or 135 mT.

Results and Discussion

We achieved consistent image quality for all volunteers, and an example 3D image set is shown in Fig. 1. Although slice-selective excitation also produced good images, it is inefficient for multi-slice imaging in PMRI, so we primarily used 3D RARE acquisitions. Figure 2 shows basic clinical contrast in PMRI, where the T_1 image gives anatomical information and the T_2 image shows long T_2 species such as fluid, which can indicate pathology. Figure 3 demonstrates the lack of imaging artifact near metal objects in the body with PMRI. These adapted methods allowed us to achieve clinically useful images on a low-cost scanner. We expect to improve the diagnostic capabilities of PMRI through further pulse sequence and hardware development, and we plan to upgrade to a 1.0T/0.2T knee-sized magnet system. The cost for an extremity PMRI scanner could someday be comparable to that of a typical ultrasound scanner.

[1] Macovski A., et. Al., MRM 1993, 30:221–30.
[2] Carlson J., et. al., SPIE 1992, pp. 22–27.
[3] Matter N., et. al., IEEE TMI 2006, in press.
[4] Hennig J, et. al., MRM 1986, 3:823–833.

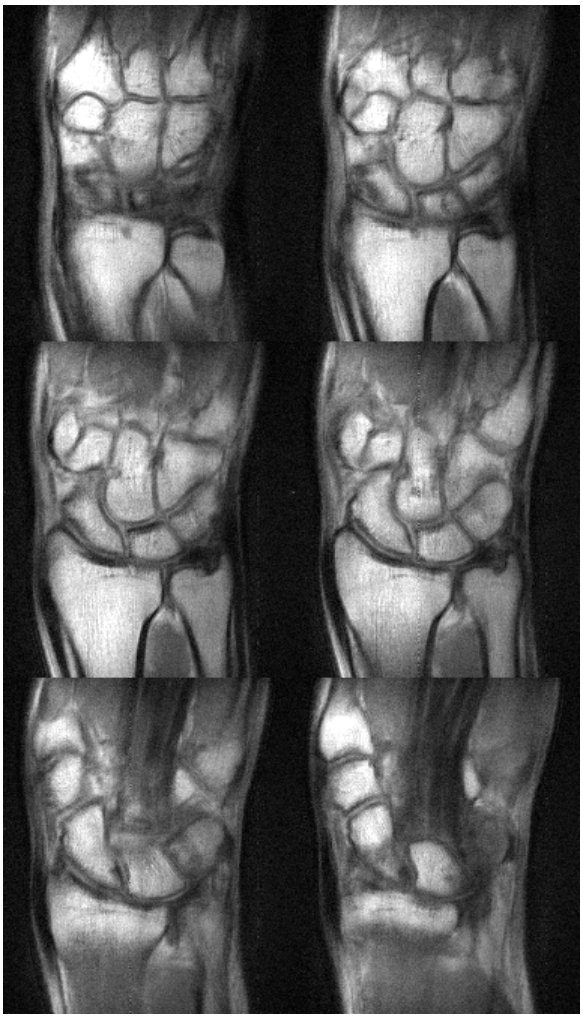
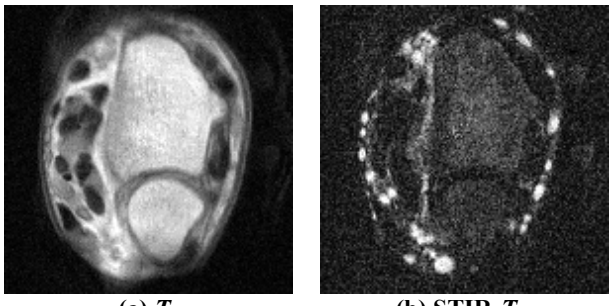
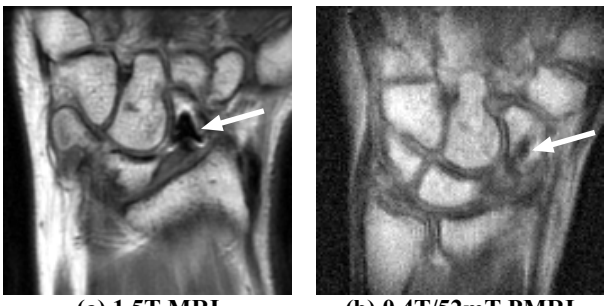


Figure 1: Subset of a 3D RARE prepolarized MRI dataset of an *in vivo* healthy wrist. This T_1-weighted image stack has a 192x384x20 matrix and a 8x16x6 cm FOV, and was acquired in 7 minutes. B_p=0.4 T; B_0=135 mT (5.76 MHz). Images are cropped to 192x224 to show detail.



(a) T_1 **(b) STIR-T_2**

Figure 2: Axial wrist images with (a) T_1 and (b) STIR fat-suppressed T_2 weighting. Blood vessels appear bright due to the longer T_2 of blood. Scan times were (a) 5.5 and (b) 7 min for 20 slices; B_p=0.4 T; B_0=52 mT.



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

Figure 3: Comparison coronal wrist images of a volunteer with a scaphoid screw (arrows). Metal susceptibility artifacts are greatly reduced in PMRI (b) compared to 1.5 T MRI (a) using 3D RARE/FSE. Scan times were (a) 6.5 and (b) 4.5 min; resolution and gradient amplitudes were matched.