Prepolarized MRI: Reducing Susceptibility Artifacts Around Metal Orthopedic Implants Without Sacrificing Image Quality

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Introduction: In 2002, over 450,000 primary or revision total knee arthroscopies were performed in the U.S. alone [1]. Yet, there are no good post-operative cross-sectional imaging methods for evaluating these patients. CT suffers from metal artifacts, and conventional MRI (0.5-3 T) suffers severe susceptibility artifacts near metal implants. Because the susceptibility-induced distortions scale with frequency [2], we can reduce metal artifacts in MR by reducing the field strength [3]. Unfortunately, in a conventional scanner this comes with linear loss of signal-to-noise ratio (SNR).

In this work, we use a Prepolarized MRI scanner to address susceptibility by acquiring the data at lower readout field (54 mT), while using a prepolarization pulse to achieve SNR comparable to that of a mid-field scanner. Here we present the first *in vivo* images that demonstrate the significant artifact reduction with PMRI while maintaining diagnostic image quality in reasonable scan times.

Methods: In this study we imaged a volunteer's wrist in a GE Signa 1.5 T scanner (General Electric, Milwaukee, WI), and with our own Prepolarized MRI scanner (0.4 T polarizing pulse, 54 mT readout field). The wrist had a steel plate along the distal radius, with four screws in the radial epiphysis and three screws in the radial metaphysis. We used 3D RARE sequences with strong gradients to address dephasing, slice-selection, and frequency-direction distortion problems near metal. At 1.5T we acquired with TE/TR = 17ms/1000ms, +/-25kHz BW, 192x192, 12cm FOV, and 3mm slice. At 54mT we acquired with TE/TR = 9ms/500ms to obtain similar contrast at lower field, but the other parameters were essentially identical. Scan times to acquire a 3D volume with 20 slices were ~6:00 at 1.5 T and 4:35 for PMRI.

Results: Figure 1 presents images of comparable coronal and axial slices at both field strengths. The 1.5 T images display characteristic voids and distortion around the steel plate and screws in both views. The PMRI images have clinically relevant image quality with significant artifact reduction.

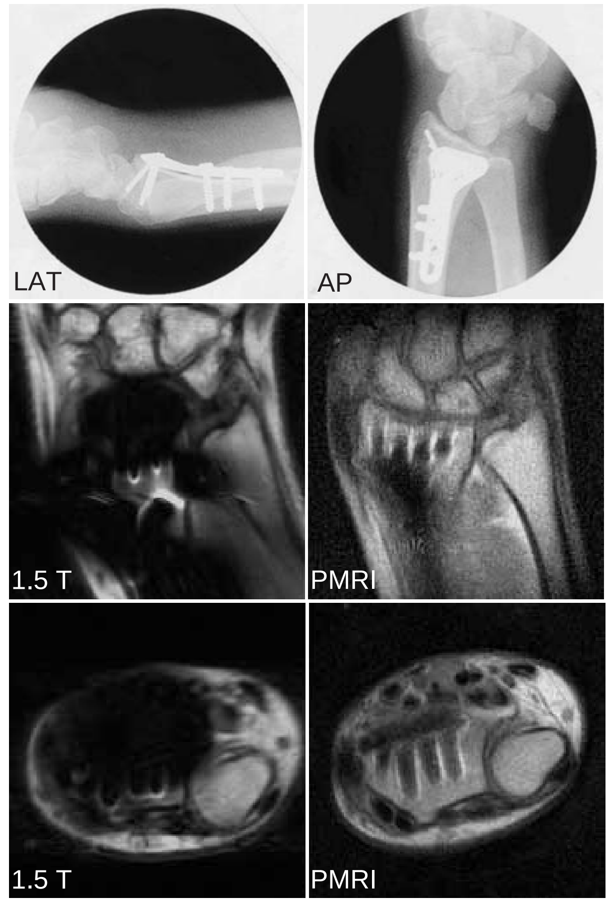

Figure 1: Comparison between 1.5 T and PMRI (54 mT). Lateral and AP radiographs (top) with coronal (middle) and axial (bottom) spin-echo MR images of an *in vivo* human wrist with a metal plate and screws. Pile-up, blowout and distortion artifacts render useless the 1.5 T images (left). The plate and screws in the PMRI images (right) have only minor artifacts, however, making it possible to visualize the alignment of the radio-carpal joint, the distal radio-ulnar joint, and the flexor and extensor tendons near the plate.

Conclusion: We have presented comparison images between our PMRI scanner and a clinical 1.5 T scanner that highlight the advantage of low-field signal reception for reducing susceptibility artifacts from metal orthopedic hardware. The quality of the PMRI images demonstrates the unique capability of this system to image around metal implants using MRI. The development of a prepolarized MRI system could present an important step forward in the post-operative monitoring and management of patients with orthopedic implants.

References

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