

A 6-element Array for Parallel Wrist Imaging at 3 Tesla

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Introduction

Parallel imaging performance is most favorable when using dedicated receiver coil arrays. Our versatile 6-element array of miniature coils was designed to take advantage of improved SNR and SENSE¹ acceleration in the wrist. Comparable commercial coils are currently not available.

Coil Construction and Characterization

Imaging of small regions such as the wrist using an array of coils requires that each coil be physically small to maximize signal strength and localization while being located as close as possible to the imaging region. Based on the average dimensions of the human wrist and desired field of view, the shape of each coil loop was chosen to be a 3.5×7cm rectangle (Fig. 1). This allows the 6 coils to be distributed tightly around the wrist in a hexagonal arrangement. Each rectangular loop was connected to a high-impedance, low-noise preamplifier through a matching network to minimize the effects of inductive coupling² and achieve low noise figure³.

The coils' individual noise performance was characterized by imaging a large aqueous phantom with a single coil. All images were acquired on a Philips Intera 3T system. Measurements of SNR under different loading conditions initially suggested that the sample noise is a minor contribution to the overall noise, as is expected given the coils' limited field of view. This noise regime was subsequently confirmed by the significant improvements observed when the coil loop or both coil loop and preamplifier were cooled by liquid nitrogen, resulting in 15% and 23% gains in SNR, respectively. Test bench measurements showed that the liquid nitrogen did not alter the electrical operation of the circuit. While accurate temperature measurements could not be obtained easily within the imaging bore, the temperature of the loop was near the altitude-adjusted nitrogen boiling point (−190°C) while that of the preamplifier was approximately −50°C. Unfortunately, using even the best room-temperature electronics it is unlikely that similar improvements in noise performance can be achieved. Noise from the electronics could thus become a fundamental limitation in arrays of a large number of small coils.

Image Acquisition and Analysis

Images of a wrist-shaped phantom were acquired to test the parallel imaging performance of the coil system. Results (Fig. 2) indicate that the coils are sufficiently decoupled and spatially unique to enable high reduction factors ranging up to the maximum value of 6 for 2D reduction. Normalized noise correlation coefficients obtained from image data span the range 0.10–0.26, corresponding to favorable coil isolation values in the range 16–26 dB⁴. High-resolution transverse images of a volunteer's wrist were acquired using the following parameters (GRE): 384×310 matrix, FOV 70×70mm², T_E 6.9ms, T_R 16.8ms, 5mm slice thickness, 182×228μm in-plane resolution, scan time 160s. Full Fourier, as well as SENSE-reconstructed images are shown in Fig. 3, confirming the array's favorable parallel imaging performance as previously assessed in vitro.

High SNR and uniformity are also illustrated by the sagittal image shown in Fig. 4. The parameters for this image were 256×256 matrix, FOV 100×100mm², TE 3.7ms, TR 7.3ms, 5mm-thick slice, 390×390μm in-plane resolution, scan time 30s.

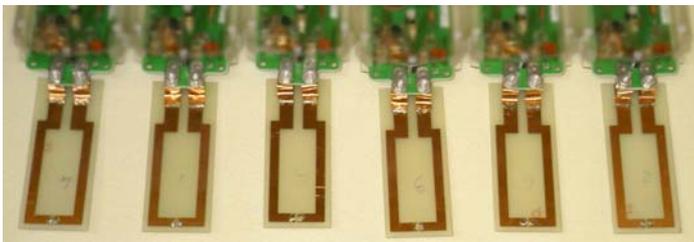


Figure 1: uninsulated wrist coil array

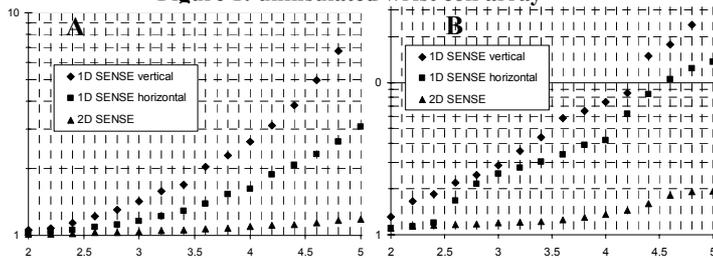


Figure 2: mean (A) and maximum (B) geometry factor, g, as a function of reduction factor, R

Conclusion

We have shown that an array of tightly-arranged, preamplifier-decoupled small coils is not only feasible but offers excellent image uniformity and SNR. In the wrist area, in particular, these benefits permit imaging with very high resolution. Using parallel imaging, the SNR advantage can be readily traded for scan speed, leading to clinically acceptable scan times. Experiments in cryogenic conditions suggest that significant further improvements in SNR could be achieved with a cooling mechanism.

References

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Acknowledgements

A fellowship (NDZ) from the Natural Sciences and Engineering Research Council of Canada is gratefully acknowledged.

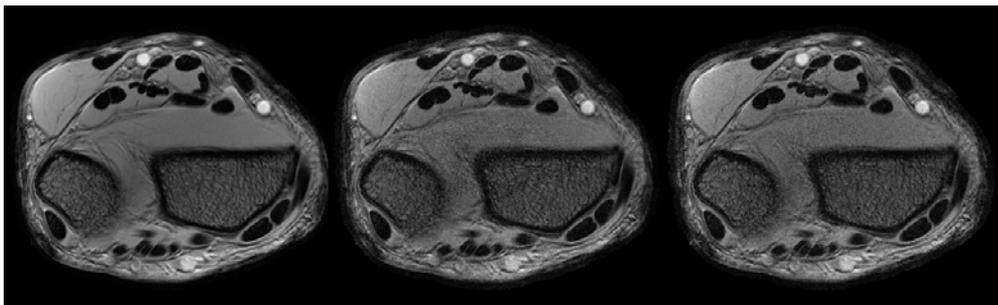


Figure 3: Full Fourier (left), SENSE×3 (1D reduction, middle), SENSE×6 (2D reduction, right) transverse images of the wrist



Figure 4: Full Fourier sagittal wrist image