# A Novel Phased Array Coil for Limb Imaging Incorporating 3D Coil Overlaps

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## Introduction

Conventional phased arrays in MR employ multiple discrete coils that are overlapped to minimize mutual inductance. While it is possible to have zero mutual inductance between two or three circular co-planar coils, it is not possible to totally eliminate mutual inductance for four or more circular coils. Furthermore, when a coil array is non-planar, canceling mutual inductance becomes even more difficult. This study presents a coil design in which the coil elements of an 8-channel array are overlapped in three dimensions to achieve low mutual inductance for optimal performance. Imaging studies were performed to explore the usefulness of a new coil design for pediatric elbow imaging and to compare quantitative and qualitative imaging findings to commercially available coils.

## Materials and Methods

An eight-channel elbow coil array (Figure 1) was designed to perform high-resolution imaging of the pediatric elbow and other anatomy (e.g. small knee, hand, etc). Seven coil elements were built into a lightweight polycarbonate U-shaped frame, and an eighth coil was built into a paddle that fits into the top of the U-shaped frame. The coil elements were constructed with 1/8" (seven lower coils), and 3/16" copper tubing (paddle coil). The dimensions of all eight coils in the array are identical; measuring 90 mm by 100 mm. A two-dimensional schematic of the coil array is depicted in Figure 2. The green coils shown in the figure are not planar, but are bent 90 degrees along the dotted lines to form a U-shaped array. Mutual inductance between the coils was minimized empirically during construction using a network analyzer operating in S21 mode, and with a dual-coil probe attached to a spectrum analyzer. Capacitors were distributed around each coil loop to minimize capacitive coupling. Each coil in the array was tuned and matched to 63.868 MHz to an adult elbow. Passive and active transmit blocking were added for safety and performance. The complete coil, including electronics and covering, weighs only 1.4 kg. The array was used with low-impedance preamplifiers to further minimize the effects of cross-coil coupling.

***Figure 1:*** *Covered elbow coil.*

MR imaging was performed on a General Electric 1.5T HDxt scanner using a routine clinical elbow imaging protocol including T1-weighted, T2-weighted, proton density weighted, Fat-Sat, Non-Fat-Sat, 2D and 3D sequences. Subjects were positioned feet-first with the elbow on the side. The "superman" position was not employed. Images obtained from the new coil and the Medical Advances 6-inch flexible coil currently used in our institution were compared for SNR. All human scanning was performed under an IRB-approved protocol.

## Results and Conclusion

Coupling between coil elements was observed to vary from -7.8 dB to -23.4 dB. The full S-Parameter matrix is displayed in Table 1. The observed isolation between coils was sufficient to support image acceleration factors of two, although higher acceleration factors are likely to be possible.

Scan positioning was reported to be comfortable by all subjects. Image SNR was observed to be 20–25% higher as compared to the flexible coil currently in clinical use at our institution. Fat saturation was uniform, indicating that the magnetic susceptibility of the coil is well-matched to human anatomy.

The new pediatric elbow coil provides excellent image quality and has the potential for improved clinical performance over existing coils. The improved SNR and isolation between coil elements promises to increase confidence in defining anatomic detail. Additional advantages provided by the new coil are expected to include shortened image acquisition times (via parallel imaging), increased SNR, and reduced motion artifact due to improved patient comfort.

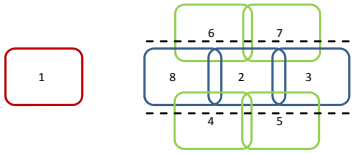
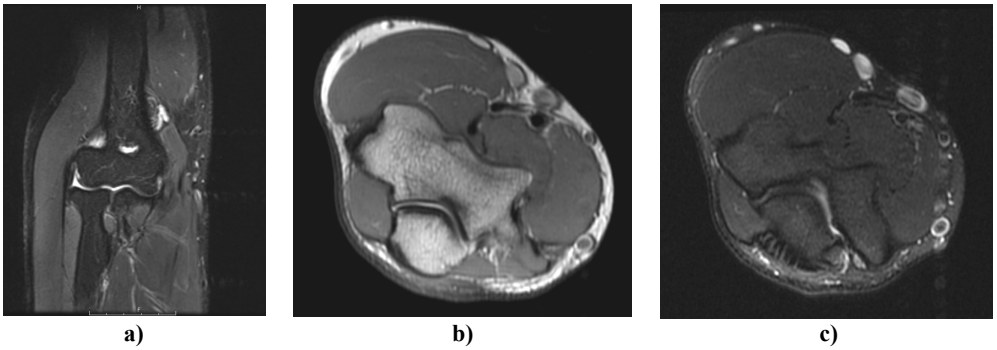



***Figure 2****: Coil arrangement. The dotted lines indicate a 90 degree fold in the green coil elements. Coil 1 is an independent paddle that fits in the U-shape formed by coils 2-8.*



**a)** **b)** **c)**

***Figure 3:*** *In-vivo images: a) Coronal STIR image of the elbow, b) Axial Proton Density image, and c) Axial FSE with fat saturation.*

***Table 1:*** *S-Parameter Matrix (dB). Entries on the diagonal are S11 measurements and entries off the diagonal are S21 measurements.*

| Ch | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | -37.9 | -8.6 | -23.2 | -9.3 | -9.7 | -13.2 | -10 | -23 |
| 2 | | -23.3 | -20.6 | -14.6 | -13.6 | -9.8 | -16.2 | -11.7 |
| 3 | | | -24.1 | -12.4 | -23.4 | -21.9 | -15.9 | -19 |
| 4 | | | | -16.4 | -8.9 | -9.7 | -13.2 | -17.1 |
| 5 | | | | | -18.9 | -13.8 | -8.3 | -12.9 |
| 6 | | | | | | -27.7 | -8.4 | -7.8 |
| 7 | | | | | | | -19.3 | -13.2 |
| 8 | | | | | | | | -25.1 |