A Multi-Element Opposed Solenoid Catheter Coil Provides Homogenous Radial Sensitivity and Extended Coverage

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INTRODUCTION

Intravascular magnetic resonance imaging (IV-MRI) has the potential to identify and characterize plaque components based on biochemical structure [1] prior to significant vessel lumen narrowing. Over 60% of myocardial infarctions result from rupture of unstable lesions with normal resting flow [2]. Previous approaches to catheter design stressed either radial signal uniformity [3] with limited vessel length visualization, or extended vessel coverage with heterogeneous radial sensitivity [4]. The goal of the present study was to develop a hybrid IV-MRI coil combining extended vessel coverage and radial signal sensitivity.

METHOD

In the opposed solenoid design the separation distance between the 2 coil elements determines the receiver coil sensitivity along the long axis. When the coils are closer than the length (L) of 1 element, sensitivity is greatest between elements (Figure 1). Conversely, >1L separation results in a drop in sensitivity between elements (Figure 2) as they begin to operate independently.

Coils were constructed with four, 10-turn elements having alternating winding direction and an optimized inter-element spacing of approximately 1L. Using a 2 capacitor resonant circuit, coils were tuned to operate at 63.6 MHz and matched to 50 Ω and interfaced via a 50 Ω, $\lambda/2$ length cable.

RESULTS

The reception profile was analytically modeled by using the Biot-Savart law with different geometric conditions (Figures 1-4). Coil element separation differences were optimized to produce homogeneous receiver sensitivity along the long axis of the coil array. Results are displayed with the array of coil elements parallel to the B_0 field. Multiple linear elements (Figure 3) displayed uniform longitudinal sensitivity over the entire multi-coil length. Bending the array 45° (Figure 4) resulted in the expected change in longitudinal sensitivity as the individual elements were tilted with respect to each other. Constructed coils had an average loaded Q-value of 81±8, and an array length of 4.8±0.6 cm.

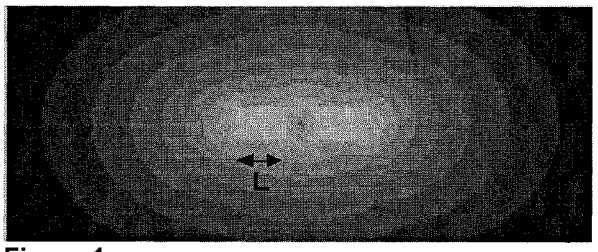

Figure 1

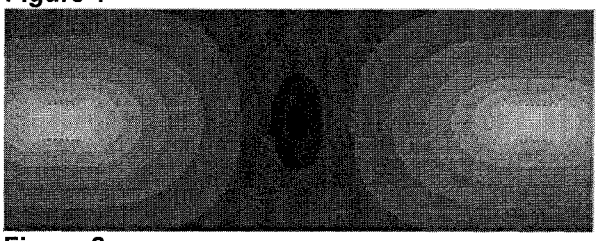

Figure 2

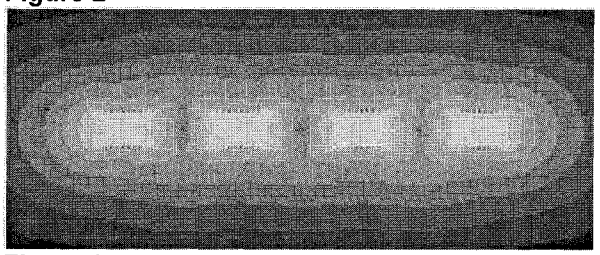

Figure 3

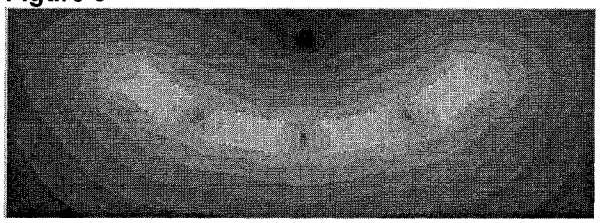

Figure 4

Conclusions

Use of multiple opposed-solenoid coil element pairs has the potential to produce uniform coil sensitivity both in the radial and along the long axis. This design may improve the detection and characterization of plaque components in extended vessel segments.

REFERENCES

[1] Rogers WJ. et al., *Circulation*; **98** (17);I-369, 1998.
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[4] Atalar, E., et al., *Magn. Reson. Med.*, **36**, 596-605, 1996.