Ground Pad for Better Look-Ahead Visualization in Guidewire Imaging

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Introduction: In interventional MRI, the use of a catheter or guidewire itself as a receiving antenna is becoming more prevalent [1]. While doing so allows delineation of the catheter or wire, it does not produce images with look-ahead ability or strong signal in front of the wire, which would be useful in imaging for total occlusions in arteries, particularly in the leg. In this work, we apply the use of a grounding pad to steer current density off of the wire in a forward looking direction, thereby increasing the receiver B_1 field, and hence signal intensity at the wire tip [2]. We compare signal from a wire with ground pad steering with signal from a twin lead, a common design for active straight guidewires because the small strip of wire at the tip induces a little signal in front of the wire [3]. With selective positioning of the return path from the ground pad or using multiple switched return paths, we attempt to increase the signal intensity at locations near the front of the guidewire.

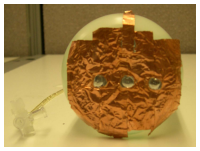


Figure 1. *Wire, ground pad, and phantom*

Methods: A twin lead design was imaged using a GRE sequence with a 4mm slice, TE = 12 ms, TR= 34 ms, and a 30° flip angle in a doped water phantom. For the wire and ground pad model, a receiver was constructed using a length of wire and impedance matching. A ground pad in the form of copper tape was attached directly to the phantom bottom, with a copper strip insulated from the phantom as a signal return path. The increased signal intensity in front of the wire was verified using the same sequence as on the twin lead with identical gain and prescan parameters. With selective placement of the return copper strip, we demonstrate changes in signal intensity in the vicinity of the guidewire.

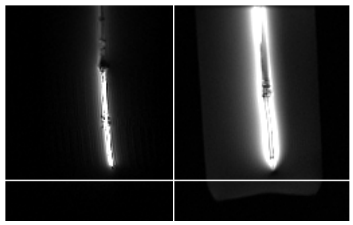


Figure 2. *Coronal views of twin lead (left) and wire with ground pad (right).*

Results: Figure 1 depicts the wire and ground pad setup for a particular return path configuration (an insulator was placed between the copper return and the phantom upon imaging). Figure 2 depicts coronal views of the twin lead and wire plus ground pad, with the white lines indicating the planes from which the subsequent axial slices were taken. Multiple images were acquired for different positioning of the return current path. Figure 3 shows images acquired for return paths oriented 45° from the vertical, in the left and right direction respectively, at axial slices 7mm in front of the wire tip. Assuming the use of any combination of return paths, we can theoretically enhance the signal intensity at a given location using a weighted average of the individual images.

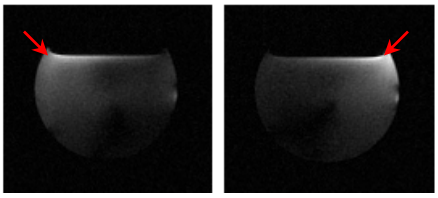
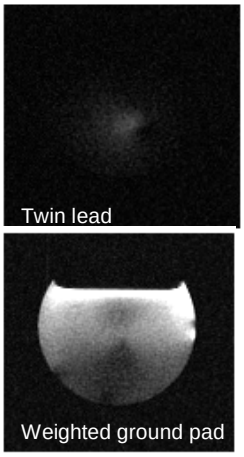


Figure 3. *Signal intensity changes depending on location of return current path at 45° from the vertical to the left (left) and right (right).*

Discussion: Figure 4 shows images of the same axial slice in the twin lead and the wire with ground pad, where the ground pad image was reconstructed by averaging the two acquired images shown in Figure 3 (the brightness level was increased to make the signal from the twin lead visible). While signal drops off very quickly at the front of the twin lead due to phase cancellation along the wire axis, we show that by using a ground pad to steer current, we can achieve higher and more uniform signal intensity in front of the wire. The internal wire and external return path effectively form an embedded surface coil field pattern. In principle, we can switch in multiple current returns, giving some ability to shape the sensitive volume. This is essentially a parallel imaging reconstruction problem, and can be solved using the same types of algorithms. This will be particularly useful in interventional MR applications involving the use of a guidewire to explore arteries, once safety concerns have been addressed.



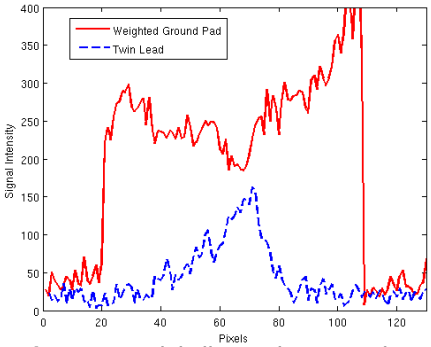


Figure 4. *Axial slices taken 7mm in front of wire tip show improvement of wire with ground pad weighted image over twin lead.*

Conclusion: Adding a ground pad to a guidewire configuration to steer current in a certain direction can enhance the signal intensity in front of the wire. This result points to improved look-ahead capability for guidewire receivers used in interventional MR.

References:

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3. Rivas PA, *et al.* J Cardiovasc Magn Reson 4(2):223-232, 2002.