Improvements to Traveling-Wave MRI Sensitivity and Homogeneity using Thin Metamaterial Bore Liners

Justin G. Pollock(1), Navid Hosseini (2), Nicola De Zanche(1), and Ashwin K. Iyer(1)
(1) University of Alberta, Edmonton, AB
(2) Middle East Technical University, Ankara, Turkey

In traveling-wave (TW) NMR, the bore of an MR scanner acts as a circular metallic waveguide that facilitates the long-range detection of the MR signal using RF antennas. For a human-sized scanner, the propagation and detection of the MR signal must occur above the circular waveguide's natural TE_{11}-mode cutoff frequency of several hundreds of megahertz, which requires a sufficiently strong static magnetic field strength (B_0) that is only satisfied by ultra-high field-strength MRI machines (7 tesla or higher). A thin metamaterial liner applied to the interior of the MR scanner bore can reduce the cutoff frequency to enable TW-based imaging using lower B_0 field strengths (e.g., 3 T) without occupying a significant amount of space within the bore (J. G. Pollock, N. De Zanche, and A. K. Iyer, "Travelling-Wave MRI at Lower B_0 Field Strength Using Metamaterial Liners", *International Society for Magnetic Resonance in Medicine Annual Meeting ISMRM 2012*, Melbourne, Australia, 2012). To do so, the metamaterial liner must possess a negative and near-zero permittivity, which may be achieved by several current metamaterial technologies.

Using full-wave simulations of a metamaterial-lined MR-scanner bore with a body-mimicking phantom inside, this work demonstrates that operating with the frequency-reduced HE_{11} mode of the metamaterial-lined bore provides improvements in sensitivity (defined as the transverse magnetic field, B_1, divided by the square root of the average or peak specific absorption rate, SAR). The liner also improves the homogeneity of the fields relative to that of the TE_{11} mode of the unlined bore, leading to potential improvements in image uniformity.