An invisibility coat to reduce RF-artefacts in Magnetic Resonance Imaging

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Considering the increment of hip arthroplasty procedures, a valid diagnostic tool able to investigate perioperative and/or postoperative diseases becomes essential. Due to its high spatial resolution, tissue contrast, sensitivity and/or specificity, Magnetic Resonance Imaging (MRI) represents a valid candidate. However, the characteristics of the Radiofrequency (RF) magnetic field B_1, responsible for the nucleus excitation and for the resulting signal, are corrupted by the presence of metallic prostheses within the body. In particular, the eddy currents generated by the interaction between the metallic object and the electromagnetic field, inevitably degrades the B_1 homogeneity leading to the rise of image artefacts. For such a purpose, we proposed to cover a metallic hip prosthesis with an ideal near-zero permittivity dielectric coat (whose relative permittivity and thickness have been tuned for the specific application) to restore the RF magnetic field homogeneity outside the prosthesis [1]. In a simulation environment, a realistic hip prosthesis stem model has been plunged into a phantom whose electric properties were similar to those provided for human muscle [2]. The phantom and the prosthesis have been radiated by means of an MRI RF antenna (i.e. an 8-leg unshielded Birdcage) and the magnetic field homogeneity has been analyzed. Numerical results showed that the presence of the dielectric coat restores the B_1 homogeneity to that obtained in absence of the metallic object, making the hip stem almost invisible to the electromagnetic radiation. In this work, several other simulations are carried out to investigate the effectiveness of the coat with a different type of RF antenna and phantom properties. In particular, an external conductive shield (commonly used for MRI Birdcages) is added to the antenna model. Moreover, the electric permittivity of the phantom is changed by ±30 % with respect to the reference value. Results show that the coat keeps restoring the original B_1 homogeneity, without being invalidated by the reasonable set-up changes that may occur in a practical application.

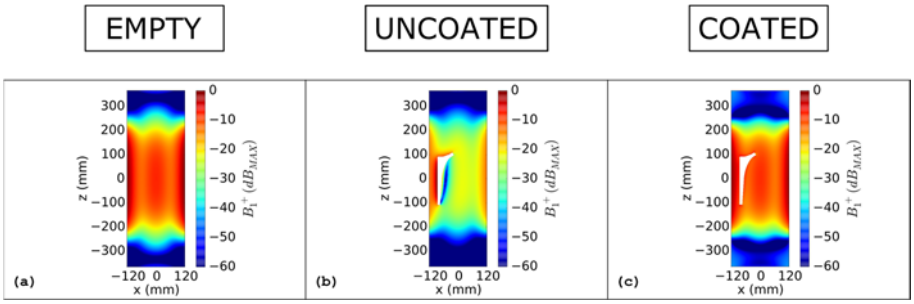

Figure 1. Rotating component of the RF magnetic field (B_1^+) referred to the maximum value of the slice: Empty case (a), uncoated (b) and coated (c) prosthesis

[1] U. Zanovello, L. Matekovits, and L. Zilberti, "An ideal dielectric coat to avoid prosthesis RF-artefacts in Magnetic Resonance Imaging," Sci Rep, vol. 7, p. 326, Mar 23 2017.

[2] S. Gabriel, R. W. Lau, and C. Gabriel, "The dielectric properties of biological tissues: II. Measurements in the frequency range 10 Hz to 20 GHz," Physics in Medicine and Biology, vol. 41, pp. 2251-2269, Nov 1996.