Estimating the electrical conductivity values in the low-frequency domain using induced current MR electrical impedance tomography – a feasibility study on phantoms

Nele De Geeter [1*], Wout Joseph [2], Roel Van Holen [3], Guillaume Crevecoeur [1], and Luc Dupré [1]

[1] *Department of Electrical Energy, Systems & Automation, Ghent University, Belgium*

[2] *Department of Information technology, Ghent University, Belgium*

[3] *Department of Electronics and information system, Ghent University, Belgium*

The accurate knowledge of electrical conductivity values of human tissue is essential for correct electromagnetic field calculations such as in EEG source imaging, neurostimulation, wave absorption in the human body and microwave ablation of tumors. At present, the electrical property database based on the 4-Cole-Cole model and created by Gabriel is used worldwide as a reference despite its inaccuracy due to *ex vivo* measurement, inhomogeneity of tissues, etc.

Recently, the induced current magnetic resonance electrical impedance tomography (ICMREIT) has been developed for the non-invasive *in vivo* assessment of conductivity at low frequencies (<10 kHz). Additional currents are induced in the subject by switching the gradient coils of the MR scanner (ECI gradient). The resulting internal magnetic flux densities cause variations of the phase image which is measured by the scanner and used to reconstruct the conductivity distribution. A priori information on the geometry based on anatomical scans is used, together with multiple ECI gradients with different time periods, so that a single parameter per tissue needs to be estimated with conservation of the frequency dependence.

In the past, a numerical study on a 4-layered spherical head model showed the successful reconstruction of the conductivity values. For a given ECI gradient and known tissue properties, an artificial phase difference was generated and acted as \'measurement\'. The feasibility of the ICMREIT technique is now demonstrated with real phantom experiments. Homogeneous cylindrical saline phantoms were constructed and by varying the salt concentration the electrical conductivity ranged from 0.01 to 1 S/m, mimicking human tissues. These values were estimated with ICMREIT and determined as well by measuring the voltage drop across the cylinder and the sourced current flow through the cylinder with electrical probes. Using this approach, this phantom study leads to the experimental validation of the novel technique.