ANATOMICALLY DETAILED HUMAN HEAD PHANTOM FOR MR TESTING PURPOSES

Sossena Wood[1], Narayanan Krishnamurthy[1], Yujuan Zhao[1], Shailesh Raval[1], Tiejun Zhao[2,3], J. Andy Holmes[4], and Tamer Ibrahim, PhD[1]

[1]*Bioengineering, University of Pittsburgh, Pittsburgh, PA, United States,* [2]*Siemens Medical System, Pittsburgh, PA, United States,* [3]*University of Pittsburgh, Pittsburgh, PA, United States,* [4]*Swanson Center for Product Innovation, University of Pittsburgh, Pittsburgh, PA, United States*

Targeted Audience: Researchers that have an interest in using a realistic anthropomorphic head phantoms to perform various test for the usage of Magnetic Resonance Imaging.

Purpose: This research was performed because there are several issues experienced at higher field strengths that hinder its clinical potential resulting in a concern of the radiofrequency (RF) power absorption in tissue and local temperature rising. These concerns, mainly safety, are evaluated through electromagnetic simulations that are compared to phantoms. However, most phantoms are not realistic nor comparable to the anatomical detail of a human head.

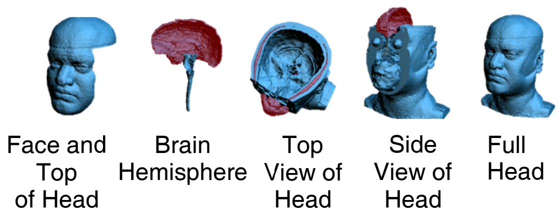

Figure 1 – Shelled CAD files to make volumetric cavities of the designated biological tissues that were segmented from Figure 1.

Table 1 – Dielectric Properties of tissues used in the 8-compatment (including nasal cavities) head phantom at 297.2MHz

	Biological Tissue	Conductivity [S/m] σ	Permittivity ϵ_r
1	Air/ Sinuses	0	1
2	Brain (WM/GM/ External CSF, Blood)	0.71	53.07
3	Cerebellum	0.97	59.86
4	Cerebralspinal Fluid (CSF)	2.22	72.80
5	Muscle/ Tendons	0.77	58.24
6	Brainstem/ Spinal Cord	0.42	36.97
7	Eyes (Lens , Cornea, Scelera)	0.92	56.46

Methods: Graedel et al. developed 4-compartment head phantom [1]. In this work, we developed an 8 compartment head phantom from segmentation of a high resolution 3T MRI dataset (Fig. 1) [2,3]. The conductivity and permittivity volumes were developed by mixtures of distilled water, $CuSo_4$, NaCl and/or ethanol for 7 tissues. The dielectric properties of each tissue were measured using a dielectric probe (SPEAG DAK) [4] with measurements calibrated between 200MHz and 310MHz with the values within Table 1. Using 3D printing, the wall thickness of each tissue compartment and final tissue (combination of fat, bone, and skin) were SLA resin (DSM Somos® WaterShed® XC 11122.) Each compartment is refillable with fluid through the chambers within the designated tissue compartment.

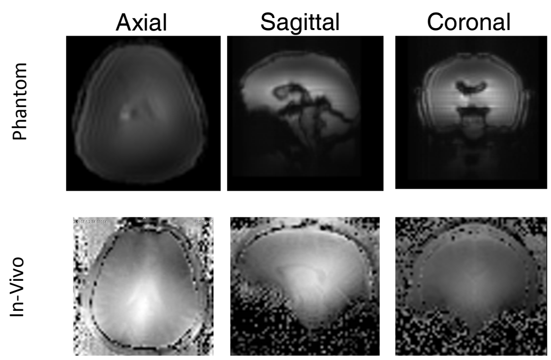

Figure 3 – Comparison of experimental B_1^+ Maps of phantom in and in-vivo in 16-element TEM head coil

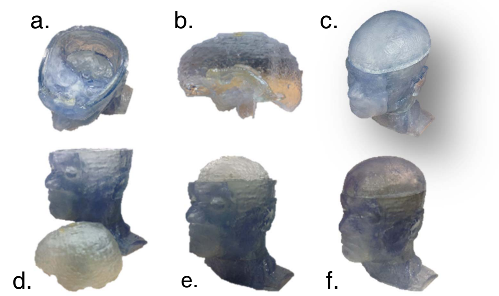

Figure 2 – Rapid Prototype of Anatomically Detailed Human Head Phantom from various angles and views (seen from a. to f.) a) top angle of full head, b) internal CSF and right brain hemisphere, c) angle of entire head., d) brain outside of head, e) brain inside of head, and f) left angle of full head.

Once filled the phantom (Fig. 2) B_1^+ Mapping and GRE sequences of the rapid prototype phantom in a 16 TEM head coil were acquired with Siemens Magnetom 7T scanner. The results of the experiments were compared to in-vivo imaging.

Discussion: The pattern of the B_1^+ maps (Fig. 3) both in-vivo and in the head phantom are similar. The GRE sequence obtained are seen in Fig 4.

Results: The B_1^+ maps and GRE sequences were qualitatively similar by comparing the pattern.

Conclusion: We built an 8-tissue compartment phantom that will be used to validate magnetic field distribution and SAR/temperature measurements/calculations. This phantom can be used for various applications of electromagnetic waves propagating through biological tissues at different RF frequencies. This work was partially supported by NIH.

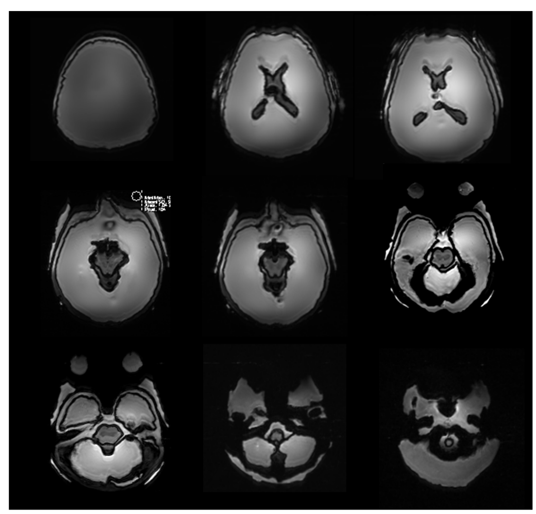

Figure 4 – Phantom GRE sequence of the head phantom in 16-element TEM head coil

References: [1] Graedel, N. (2012) ISMRM; [2] Tech, Z.M. iSeg. 2011: Zurich Switzerland [3] Geomagic, Geomagic Studio: Morrisville, NC. 2012. [4] SPEAG, DAK. 2013: Zurich, Switzerland.