URSI AP-RASC 2019, New Delhi, India, 09 - 15 March 2019

A Geometry-Variable Tcoil for the Medical Application of Transcranial Magnetic Stimulation

M.Liu[(1)], S.Liu[(1)], M.A.Yedeas[(1)], Y.Kawasaki[(1)], M.Sekino[(1)]
(1) The University of Tokyo, Tokyo, 113-0032, e-mail: liu-mf13@bee.t.u-tokyo.ac.jp; liu@bee.t.u-tokyo.ac.jp; amine@bee.t.u-tokyo.ac.jp; Kawasaki@bee.t.u-tokyo.ac.jp; sekino@bee.t.u-tokyo.ac.jp

Transcranial magnetic stimulation (TMS) is effective, painless and non-invasive in the treatment of neurological and psychiatric diseases. However, the distribution of the electric fields induced by TMS is affected by the individual variability in the shape of the human head and by the targeted area of the brain. Thus, the efficiency of the existing TMS coils varies considerably among patients because of their fixed geometries. In this study, we designed a Twin coil (Tcoil), which consists of figure-eight coil with bending wings, and tested its adaptability. The coil efficiency was defined by the value of the average induced eddy current density in the targeted area of the brain for the same driving current intensity. Numerical simulations were conducted on both the conductive sphere head model as well as the real brain models constructed from Magnetic Resonance(MR) images of five healthy human subjects, by the scalar potential finite difference (SPFD) method. The depth and focality characteristics of the stimulation induced by the Tcoil for bending angles from 90° to 180° (figure-eight coil configuration) were studied then. And we measured the induced eddy current in the motor cortex left hand, foot, and face areas of the real brain models by the Tcoil for different bending angles (In Silico). The results show that the stimulation efficiency varies considerably among the subjects and also the different brain areas. And we adapted shape of the geometry-variable to obtain the most efficient stimulation by defining the best bending angle in each case, with a considerable increase in efficiency compared to the baseline figure-eight coil. Furthermore, a direct link between the coil angle and the induced eddy current was also established. Through the study on the conductive sphere model, we demonstrate that the Tcoil can be used to provide focused stimulations and deep stimulations depending on the bending angle, covering a wide area of the TMS applications. Finally, we measured the magnetic flux density generated by the Tcoil prototype and found that by bending the coil, a stronger magnetic field with a higher field penetration can be obtained.

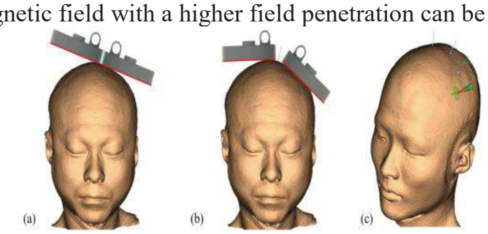

Figure 1. (a) Head model of subject 2 constructed form MR images and the Tcoil with 180° bending angle in the position defined by medical doctors for the stimulation of the foot area of the brain. (b) Same head model and the Tcoil with 140° bending angle. (c) Head model of subject 5. The blue picks represent the stimulation points indicated by medical doctors using a neuronavigation system.

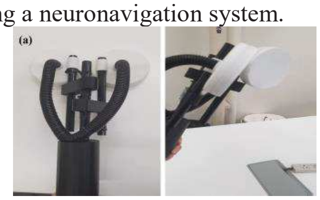

Figure 2. Twin coil prototype

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