

Application of photothermal therapy with photoacoustic temperature monitoring in the mouse's head: a numerical study

Antoine Capart^{(a)*}, Khaled Metwally^(a,b), Chiara Bastiancich^(c) and Anabela Da Silva^(a)

^(a) Aix Marseille Univ, CNRS, Centrale Marseille, Institut Fresnel, Marseille, France

^(b) Aix Marseille Univ, CNRS, Centrale Marseille, LMA, Marseille, France

^(c) Aix Marseille Univ, CNRS, UMR 7051 Institut Neurophysiopathologie, Marseille, France

* antoine.capart@fresnel.fr

Abstract: We present here a numerical study of a photothermal therapy conducted on a digital phantom of a mouse's head bearing a tumor. The temperature evolution and thermal damages caused to the phantom and the tumor were calculated using heat diffusion simulations. Nanoparticles were simulated in the study as a local increase of the tumor's absorption and their effect on the therapy is studied. Finally, photoacoustic simulations were performed in order to monitor the temperature evolution in the tumor during the therapy.

PhotoThermal Therapy (PTT) designates the use of optical radiation in order to induce rises in temperature sufficient to induce the death of cells involved in a given pathology (cancer). PTT has grown in popularity in recent years as a result of its targeted and non-invasive therapeutic benefits. With its constant improvement, new effective numerical methods for the modeling of this therapy are developed to confront numerical and experimental results. Following these approaches and with the aim of clarifying experimental results, we developed a numerical phantom of a mouse's head where PTT was performed. The phantom, presented in Fig.1, was built using open-source atlases obtained with different imaging methods [1-4] to mimic as realistically as possible the morphology of the mouse's head.

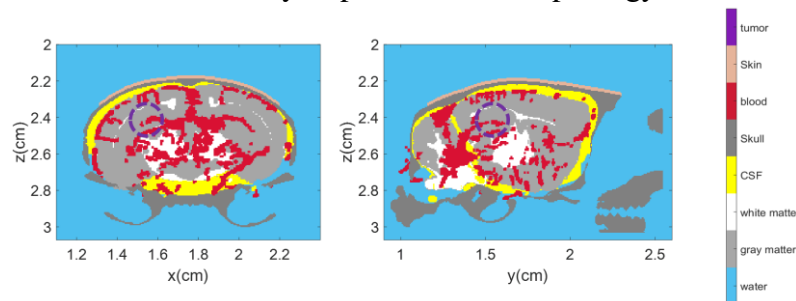


Fig. 1 : Phantom of a mouse's head: 2D sagittal and cortical view. Tumor's position is indicated by the dashed purple line.

The effect of using nanoparticles, often used in PTT to improve the efficacy of the therapy, has been studied. During the therapy, a temperature monitoring method is needed in order to evaluate the progression of the therapy. The photoacoustic (PA) technique was chosen for such purpose: PA signals were calculated and variations of these signals observed during the therapy were linked to temperature evolution in the tumor.

[1] Y. Ma et al., 'A Three-Dimensional Digital Atlas Database of the Adult C57BL/6J Mouse Brain by Magnetic Resonance Microscopy', *Neuroscience* 135, no. 4 (1 January 2005): 1203–15.

[2] E. Chan et al., 'Development of a High Resolution Three-Dimensional Surgical Atlas of the Murine Head for Strains 129S1/SvImJ and C57Bl/6J Using Magnetic Resonance Imaging and Micro-Computed Tomography', *Neuroscience* 144, no. 2 (19 January 2007): 604–15.

[3] A. Dorr, J.G. Sled, and N. Kabani, 'Three-Dimensional Cerebral Vasculature of the CBA Mouse Brain: A Magnetic Resonance Imaging and Micro Computed Tomography Study', *NeuroImage* 35, no. 4 (May 2007): 1409–23.

[4] Yuming Liu et al., 'OptogenSIM: A 3D Monte Carlo Simulation Platform for Light Delivery Design in Optogenetics', *Biomedical Optics Express* 6, no. 12 (1 December 2015): 4859.