ABSTRACT (English)

Contrast enhancement in optical coherence angiography for brain imaging

The doctoral dissertation entitled “Contrast enhancement in Optical Coherence Angiography for Brain imaging” prepared by Mounika Rapolu under the supervision of Prof. hab. Maciej Wojtkowski submitted on 06-08-2021.

Monitoring of treatments of brain traumas and brain diseases requires continuous control of quantitative parameters describing the state of rodent brain vascularization. The introduction of new biomarkers allowing objective evaluation of progression or regression of development of new pathological vessels or atrophy of existing vessels requires to optimize imaging conditions. In particular, it is important to achieve high contrast for all capillaries located throughout the sub-cranial layer. The contrast improvement in angiographic imaging of the rodent brain vasculature in the presence of pathological changes by Optical Coherence Microscopy (OCM) can be accomplished by varying the physical experimental conditions affecting any of parameters such as: amplitude of light scattered from blood, geometry of illuminating beam, timing and settings of raster scan. The Bessel beam OCM promises to overcome the problem of the penetration depth and offers better extended focus to be applied to image the turbid tissue medium. It is a potential candidate in providing the information of the dynamics of blood circulation and gives a better new perspective for the monitoring the key parameter in activation of these stroke in brain in pathophysiological pathway. We introduced a system based on a Bessel beam and performed a comparison with a classical system illuminating the sample with a Gaussian beam. We have analyzed the advantages and disadvantages of this solution for a very specific application - to brain imaging by Optical Coherence Microscopy Angiography (OCM-A).

The contrast agents like intralipids or Large Gold Nanorods (LGNRs) are used to increase the imaging sensitivity for ex-vivo and in-vivo studies. They help to increase the contrast of the OCM signal and observe fine details in the deeper regions within intact tissue. But there are only quite a few groups working on LGNRs for biomedical studies despite their advantage of increasing the contrast of the OCM signal. We studied whether the introduction of nanoparticles enhance the infrared scattering using plasmon resonance enables OCM-A signal enhancement. We also studied if the introduction of nontoxic scattering enhancement agent intralipids in blood to improve the OCM-A contrast.

Finally, we evaluated the impact of proper selection of OCM-A scanning protocols on the quality of angiographic imaging in the presence of lesions and proposed a new method to improve the OCM-A contrast without contrast agents.

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