Robustness of the wide-field imaging Mueller polarimetry for brain tissue differentiation and white matter fiber tract identification in surgery-like environment

O. Rodríguez-Núñez * [1], L. Felger[1], R. Gros[2,3], T. Maragkou[2], Richard Mckinley[4], S. Moriconi[4], T. Novikova[5], A. Pierangelo[5], P. Schucht[1]

[1]*Department of Neurosurgery, Inselspital, Bern University Hospital, Bern*

[2]*Institute of Tissue medicine and Pathology, University of Bern, 3010, Bern, Switzerland*

[3]*Graduate School for Cellular and Biomedical Sciences, University of Bern, 3010, Bern, Switzerland*

[4]*SCAN, University Institute of Diagnostic and Interventional Radiology, Inselspital, Bern University Hospital, Bern, Switzerland*

[5]*LPICM, CNRS, Ecole Polytechnique, IP Paris, Palaiseau, France;*

**omar.rodrigueznunez@gmail.com*

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Aims. A real-time, non-invasive, dye- and contact-free brain tissue differentiation during tumor neurosurgery is a challenge we address with the wide-field imaging Mueller polarimetry (IMP) [1, 2]. In our prior studies we demonstrated that IMP is capable to detect correctly the in-plane orientation of brain white matter fiber tracts of a flat formalin-fixed thick brain specimen. Here we demonstrate the versatility and robustness of IMP data for the detection of cerebral white matter fiber tracts in the adverse conditions similar to those present in neurosurgery, such as uneven surfaces and presence of blood and irrigation fluids.

Methods. We used the non-contact wide-field IMP system [3] operating in a visible wavelength range in reflection configuration for surface imaging in 3 settings using fresh cadaveric calf brain. First, we performed MP images of coronal sections and repeated the images after removing a thin layer of white matter using a cavitron ultrasonic surgical aspirator (CUSA) comparing their respective polarimetric characteristics. Next we mimicked lesion resection by performing 3 cm-deep resection cavities with i) a scalpel and ii) a CUSA commonly used in neurosurgery in order to compare the corresponding polarimetric maps. Lastly, we performed tests with dilution series of blood spilled on prepared white matter specimen and measured the Mueller matrix images acquired at 550nm and 650nm, processed with Lu-Chipman decomposition algorithm [4].

Results. For uneven surfaces due to ultrasonic aspiration and within resection cavities made with scalpel and CUSA, the measurements performed with IMP system maintained their respective sensitivity. The orientation of the white matter fiber tracts was clearly visualized in the image of the azimuth of the optical axis. At the same time, the presence of blood/saline solution up to a thickness of 2mm did not significantly impact the orientation maps.

Conclusion. Our wide-field IMP system produces robust results on fiber tract visualization under all adverse, neurosurgery-like conditions, rendering it a potential new tool for an intra-operative, real-time, non-invasive identification of brain tumor borders and brain fiber tract orientation.

References:

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