An intraoperative spectroscopic imaging system for quantification of Protoporphyrin IX during glioma surgery

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ABSTRACT

Cancer tissue often remains after brain tumor resection due to the inability to detect the full extent of cancer during surgery, particularly near tumor boundaries. Commercial systems are available for intra-operative real-time aminolevulenic acid (ALA)-induced protoporphyrin IX (PpIX) fluorescence imaging. These are standard white-light neurosurgical microscopes adapted with optical components for fluorescence excitation and detection. However, these instruments lack sensitivity and specificity, which limits the ability to detect low levels of PpIX and distinguish it from tissue auto-fluorescence. Current systems also cannot provide repeatable and un-biased quantitative fluorophore concentration values because of the unknown and highly variable light attenuation by tissue. We present a highly sensitive spectroscopic fluorescence imaging system that is seamlessly integrated onto a neurosurgical microscope. Hardware and software were developed to achieve through-microscope spatially-modulated illumination for 3D profilometry and to use this information to extract tissue optical properties to correct for the effects of tissue light attenuation. This gives pixel-by-pixel quantified fluorescence values and improves detection of low PpIX concentrations. This is achieved using a high-sensitivity Electron Multiplying Charge Coupled Device (EMCCD) with a Liquid Crystal Tunable Filter (LCTF) whereby spectral bands are acquired sequentially; and a snapshot camera system with simultaneous acquisition of all bands is used for profilometry and optical property recovery. Sensitivity and specificity to PpIX is demonstrated using brain tissue phantoms and intraoperative human data acquired in an on-going clinical study using PpIX fluorescence to guide glioma resection.

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