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Using optics to detect positive surgical margins intraoperatively during prostate cancer surgery

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Introduction & Objectives: Currently, there is no accurate technique available to detect Positive Surgical Margins (PSM) intraoperatively during robotic-assisted laparoscopic prostatectomy. Diffuse Reflectance Spectroscopy (DRS) is an optical technique that can measure tissue composition and morphology based on the optical characteristics of the tissue. This technology has proven to be effective in discriminating different tissue types in other fields of cancer surgery and can thus potentially be used for real-time in vivo detection of PSM during prostate cancer surgery. This study focuses on using DRS to discriminate tumor tissue from non-tumor tissue in robot-assisted prostate cancer surgery.

Materials & Methods: DRS measurements were obtained with a fiber-optic probe from 40 ex vivo prostatectomy samples in the wavelength range between 400 and 1600nm. Measurements were acquired both at the prostate surface and the cleaved prostate surface. Prostates with an apical tumor were included, to ensure that the tumor would be exposed when cleaving the prostate to mimic a PSM. The measurement locations were annotated by a trained uro-pathologist. The measured spectra were labeled based on these histopathology annotations. From the measured spectra, features were extracted to distinguish tumor tissue from non-tumor tissue, glandular tissue, and connective tissue, respectively, based on the calculated slope for each wavelength. These features were used as input for a machine learning-based classification model. The accuracy, sensitivity, and specificity of this classification model were calculated.

Results: A total of 120 measurements on the prostate surface and 150 measurements on the cleaved prostate surface were obtained. For measurements on the prostate surface, a decision tree-based classification algorithm could distinguish tumor tissue from non-tumor tissue with an accuracy of 78.3%, sensitivity of 60.0%, and a specificity of 82.0%. These numbers improved when differentiating different types of non-tumor tissue. In distinguishing tumor tissue from, for example, glandular tissue this led to an accuracy of 84.2%, sensitivity of 90.0%, and specificity of 77.8% to distinguish prostate cancer tissue from glandular tissue.

Conclusions: It is concluded that DRS has the potential to discriminate non-tumor tissue from tumor tissue with sufficient accuracy. The in vivo application of this technology could help surgeons in nerve sparing surgery while preventing positive surgical margins. These results suggest that DRS can be used to distinguish tumor tissue from non-tumor tissue. Further research will focus on in vivo use of DRS.