**Ex vivo prostate study of an enhanced 12-core biopsy with electrical impedance**

Ethan K. Murphy[1], Xiaotian Wu[1], Alicia C. Everitt[1], Jason Pettus[2,3], and Lawrence M. Dagrosa[2,3], and Ryan J. Halter[1,2], ethan.k.murphy@dartmouth.edu

*[1]Thayer School of Engineering, Dartmouth College, [2]Geisel School of Medicine, Dartmouth College, Hanover, NH, [3]Dartmouth-Hitchcock Medical Center (DHMC), Lebanon, NH*

**Introduction and overall goal**. The goal of this study was to evaluate an enhanced 12-core biopsy technique on 22 recently excised prostates using Electrical Impedance (EI) (data and imaging) to assess its potential to improve detection and grading of prostate cancer.

**Specific aims**. To statistically asses EI's ability to discriminate tumor cores (defined by a distance from the needle to tumor) from benign cores, and correlate EI with Gleason Grade Group.

**Rationale and background.** Prostate cancer represents the 2nd leading cause of cancer-related death in men and has a significant societal impact with 1 in 9 men being diagnosed with the disease. The standard approach for diagnosing prostate cancer is through a 12-core transrectal ultrasound (TRUS)-guided biopsy procedure, during which small tissue cores are systematically extracted across the whole prostate, which can miss 10-30% of all cancers (probing < 1% of prostate volume). Additionally, while multi-parametric magnetic resonance (mpMRI) approaches are exhibiting success and becoming more common, they still struggle to accurately discriminate between aggressive and indolent disease. Numerous studies have found significant ($p<0.001$) electrical property contrast between benign and malignant prostate tissues ([2], [3]) and more importantly significant electrical property differences between high- and low-grade cancer ([4]). By collecting EI data using electrodes near the tip of a standard biopsy needle we may be able to leverage prior results and eventually improve clinical care and detection for patients.

**Methods and materials**. A 12-core biopsy of the ex vivo prostate was performed wherein EI, electromagnetically (EM)-tracking data, and biopsy cores were collected. A total of 22 ex vivo prostates were removed during RALP by a single surgeon (Dr. Dagrosa) at DHMC under an IRB approved protocol from consenting individuals. Following the experiment EM-registration data and an MR were collected and the prostate was sent for histological assessment, wherein tumor boundaries were recorded on MR images. Data was fused together resulting in ~200 cores from the 22 prostates with usable data, i.e. tissue properly collected and all labeling and registration data is consistent. Data was analyzed in terms of tumor-cores (defined by a distance from the needle (*Tc*)) and benign cores (> 10 mm from needle) and a 2-metric (EI and image-based metrics) in terms of accuracy, sensitivity, and specificity versus tumor distance.

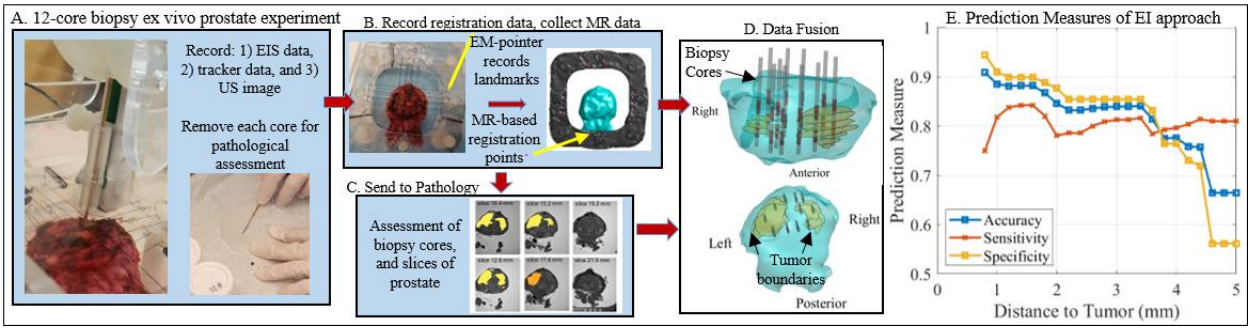


*Fig. 1. Flow chart of the experiment (A-D) and prediction quality vs distance to tumor.*

**Results**. The 2-metric approach achieved sensitivity, specificity and accuracy of 0.85, 0.93, and 0.92 for $Tc = 0.8$, and the accuracy stays high (0.88) until $Tc = 1.6$ (Fig. 1E), which equates to ~9.6% sensed volume (10x more than a standard biopsy). Gleason grade was significantly correlated to conductivity (an imaging metric) if normalized by size and distance ($p=0.012$).

**Discussion and conclusion.** These promising results strongly support the role EI might have in improving detection, diagnosis and care for prostate cancer patients. Such results warrant further study in an in vivo setting.

**References.**

1. R. J. Halter, et al., "Electrical Properties of Prostatic Tissues: I. Single Frequency Admittivity Properties," J. Urol., vol. 182, no. 4 SUPPL., pp. 1600–1607, 2009.

2. G. Salomon et al., "The Feasibility of Prostate Cancer Detection by Triple Spectroscopy," Eur. Urol., vol. 55, no. 2, pp. 376–384, 2009, doi: 10.1016/j.eururo.2008.02.022.

3. R. J. Halter, A. R. Schned, J. A. Heaney, and A. Hartov, "Passive bioelectrical properties for assessing high- and low-grade prostate adenocarcinoma," Prostate, vol. 71, no. 16, pp. 1759–1767, 2011.