Making Our World Healthier and Safer

AUA-2020
MAY 15-18 washington, dc

(PD23-06) Kidney tumor detection with histological subtype differentiation using Molecular Chemical Imaging

Arash Samiei[1], Shona Stewart[2], Ralph Miller[1], John Lyne[1], Aaron Smith[2], Marlena Darr[2], Heather Gomer[2], Patrick Treado[2], Jeffrey Cohen[1,2]

[1]Allegheny General Hospital, Division of Urology, Pittsburgh, Pennsylvania

[2]ChemImage Corporation, Pittsburgh, Pennsylvania

ChemImage®

Allegheny Health Network

Motivation

Visualization & high confidence detection of tumor in real time with ability to differentiate the histological subtypes

SURGEONS NEED

- Real-time visualization and detection of tumors during extirpative surgeries can be challenging
- To reduce the chance of positive surgical margin by identifying the tumor tissue with high accuracy.

CURRENT CHALLENGES

- Currently, there is no intraoperative imaging device to detect kidney tumors and determine their histological subtype with high accuracy
- Contrast agents, which may be available for certain targets during surgical procedures add extra steps to surgical workflow

OUR STUDY

- We have reported the performance of tumor differentiation from normal tissue using Molecular Chemical Imaging (MCI) previously and in this study our goal is to show the performance of tumor histological subtype identification using this technology.

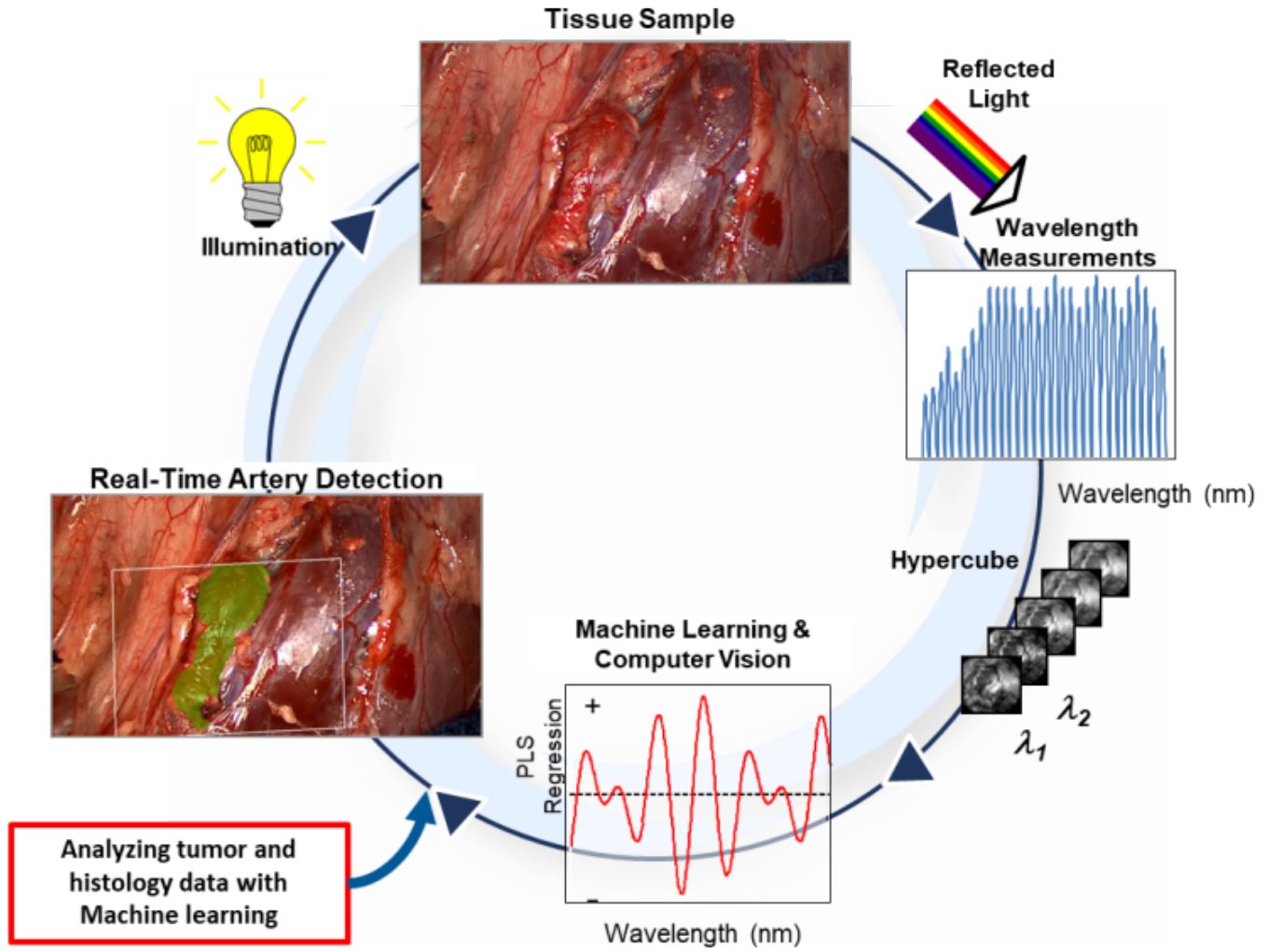
Allegheny Health Network

Molecular Chemical Imaging

Integrates optical spectroscopy and digital imaging to produce molecular-specific images.

Advantages of MCI:

- Uses regular white light
- No contrast agent needed
- Non-invasive
- Analyzes the tissue's behavior toward light (reflection and absorption)
- Discriminates tissues with high sensitivity and specificity
- Detects targets in real time using machine learning algorithms
- Creates high contrast video output



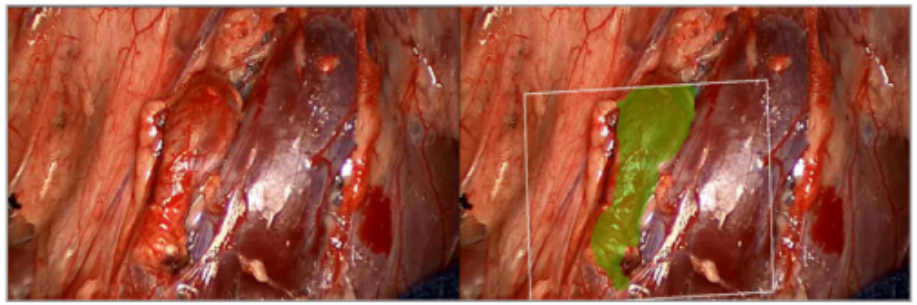
Allegheny Health Network

ChemImage®
www.chemimage.com

Real-time Pre-Clinical Studies Results

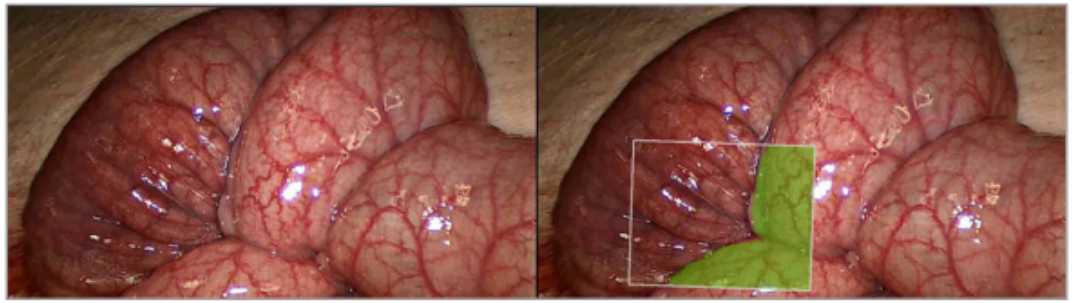
Critical Structure Detection

Abdominal Artery RGB | MCI Detection Overlay



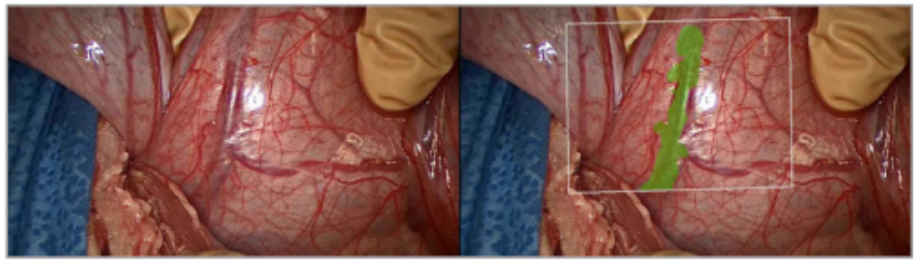
Perfusion Detection

Blood-restricted and Perfused Bowel | Perfused Bowel MCI Detection Overlay



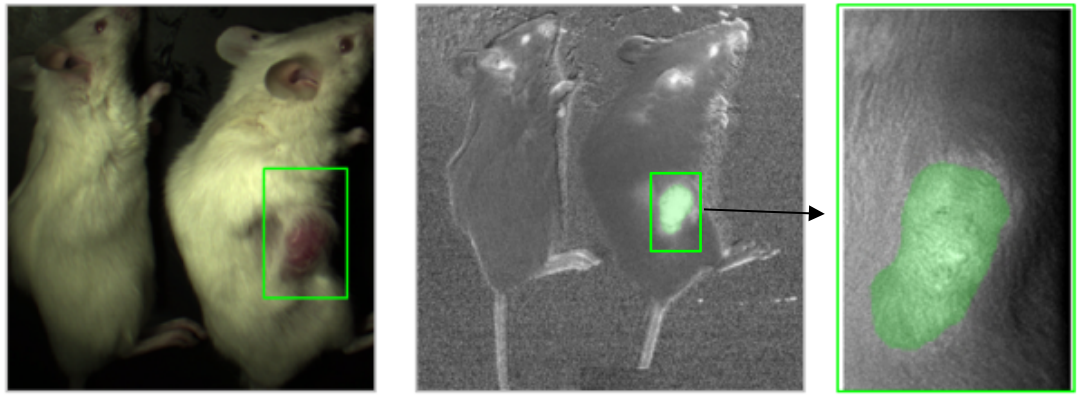
Critical Structure Detection

Abdominal VeinRGB | MCI Detection Overlay



Tumor Detection

Intact, Sedated Mice | Tumor Detection Image



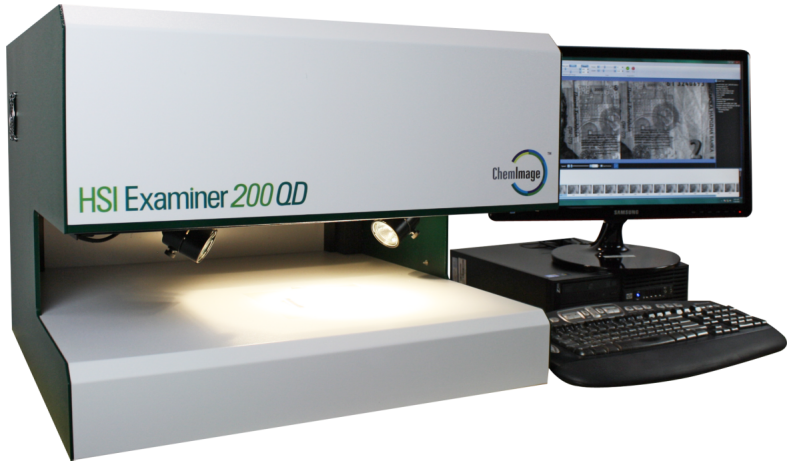
Allegheny Health Network

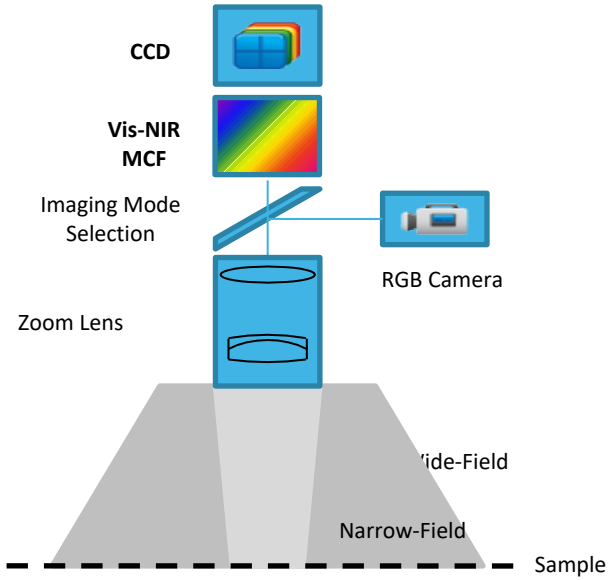
ChemImage

www.chemimage.com

Material and Method

- We studied 22 human kidney cancer specimens after partial or radical nephrectomy.
- Tumor subtypes from 18 specimens were further investigated.
- A multi-class partial least squares discriminant analysis (PLS-DA) model was built from
  - 13 clear cell renal cell carcinomas (RCC)
  - 2 papillary RCC
  - 2 transitional cell carcinoma (TCC)
  - 1 chromophobe RCC
- Subtype classification accuracy for each tumor subtype was generated.





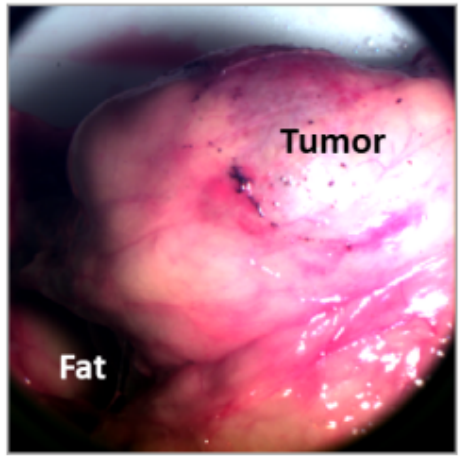
Allegheny Health Network

ChemImage
www.chemimage.com

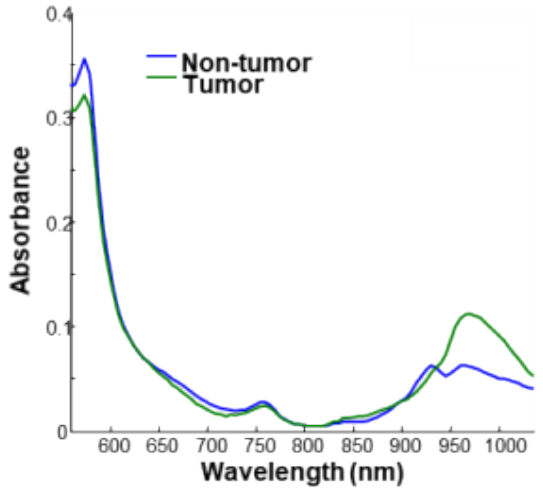
Results

MCI score images of human renal tumor (*tumor vs non tumor detection)*

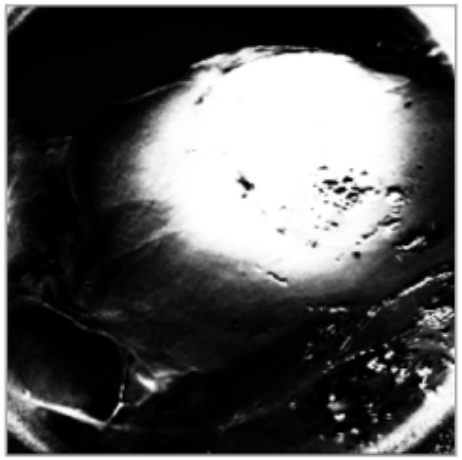
RGB Image



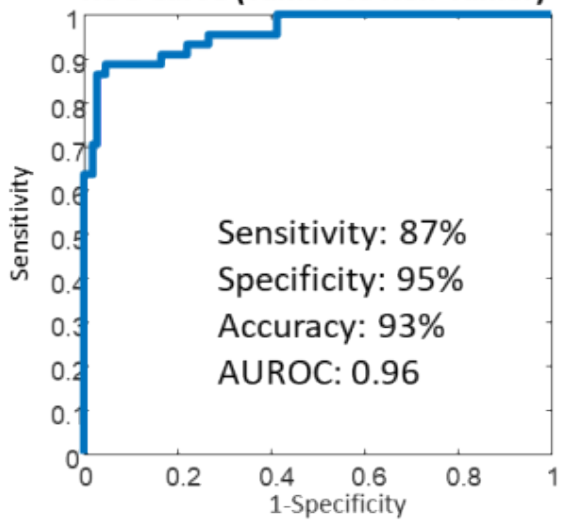
Average Vis/NIR Spectra



Tumor Probability Image



ROC Curve (Tumor vs Non-Tumor)



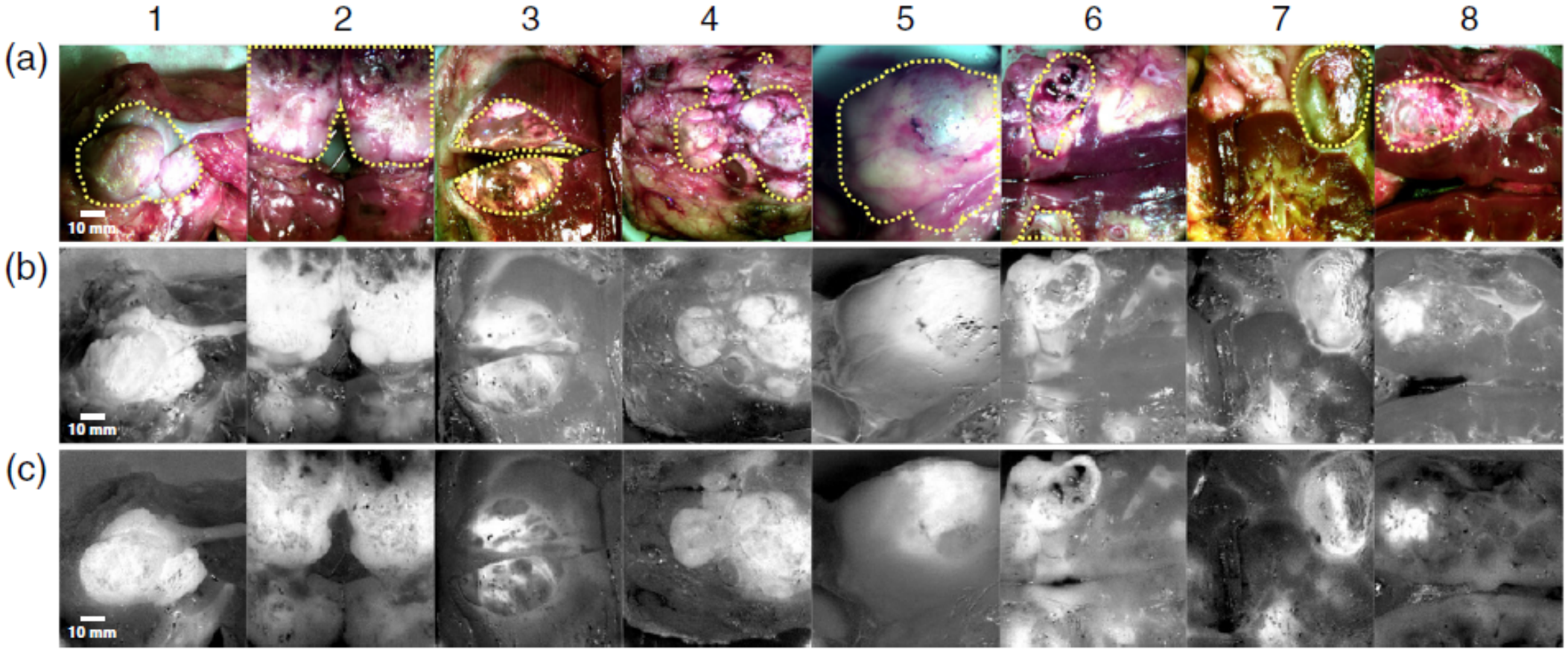
- The PLS-DA model for tumor discrimination exhibits high performance with 93% accuracy, 87% sensitivity, 95% specificity, and 0.96 AUROC.

Allegheny Health Network

ChemImage®
www.chemimage.com

Results

MCI score images of human renal tumor (*tumor vs non tumor detection)*



(a) RGB images, generated from MCI hypercubes with tumor annotations in yellow.
(b) PLS-DA score images generated by applying the PLS-DA model to representative MCI hypercubes. Higher pixel intensity indicates a higher probability of tumor
(c) Ratiometric score images. Contrast of tumor pixels (higher intensity) against darker background pixels is created with the ratio of two optimal wavelength images: 915/1000 nm

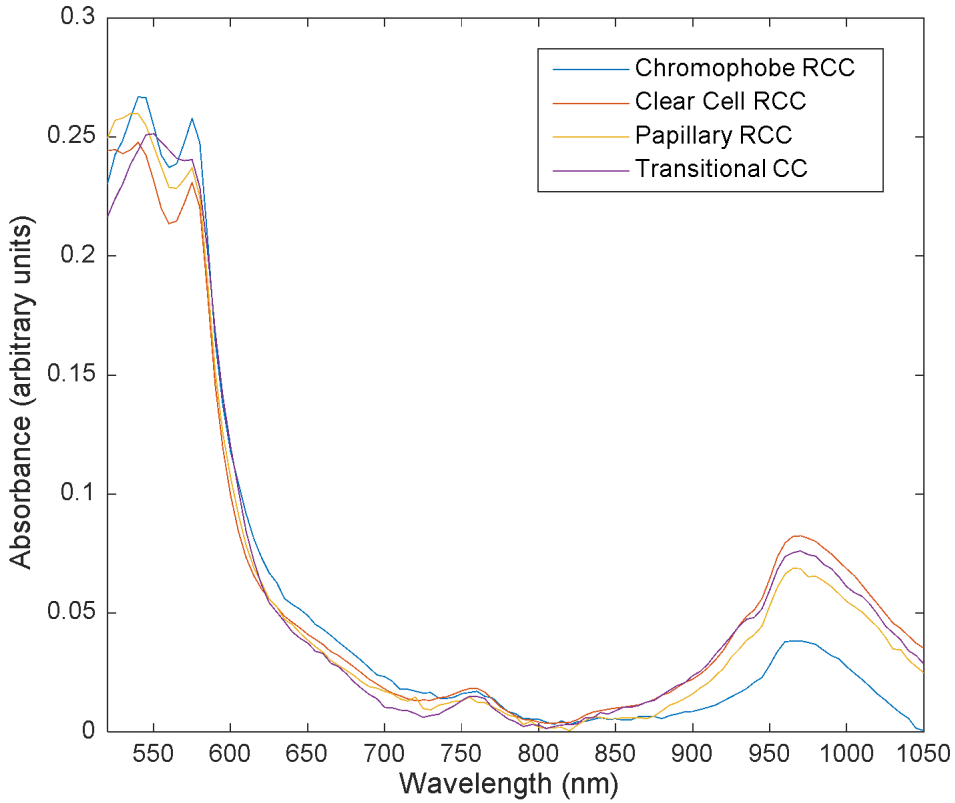
Stewart, et.al., J. of Biomedical Optics, 25(2), 026003 (2020). https://doi.org/10.1117/1.JBO.25.2.026003

Allegheny Health Network

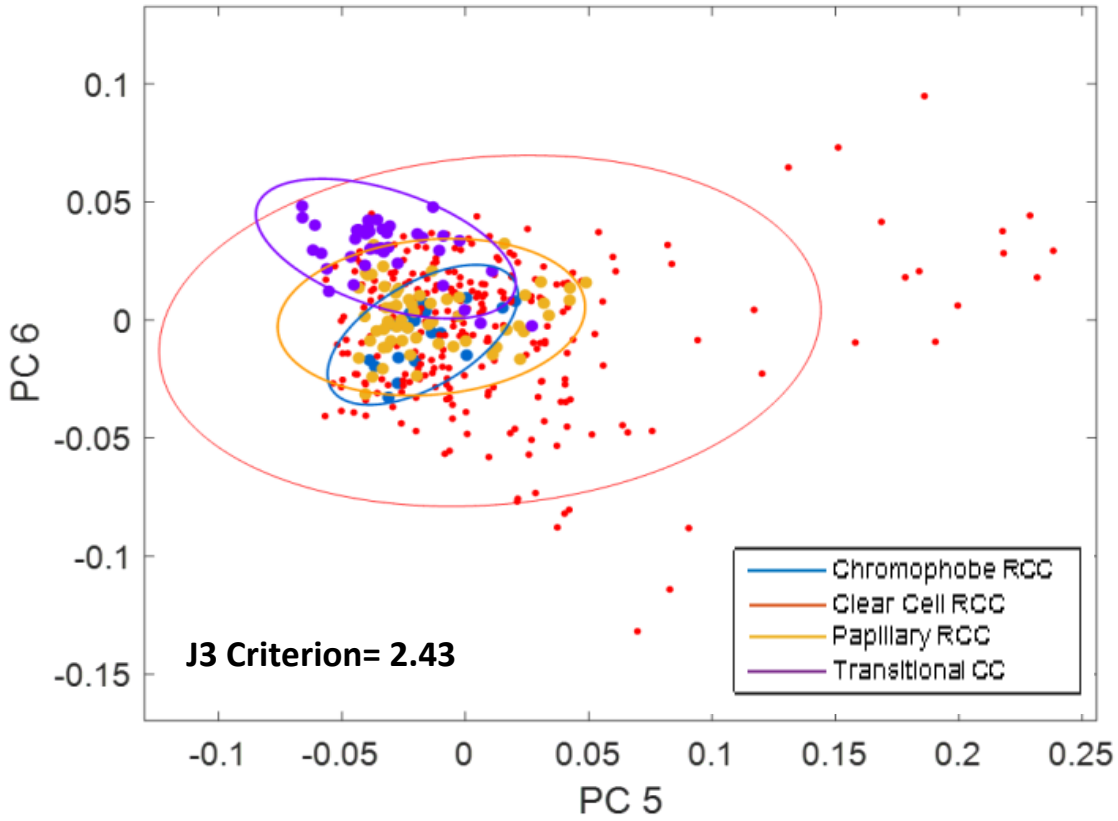
Results

Signature Analysis (*tumor histological subtype differentiation*)

Average Vis-NIR Spectra



Scatterplot



18 Patients

PLS-DA, Leave-one-field-of-view-out (LO-FOVO) cross validation

Allegheny Health Network

ChemImage®
www.chemimage.com

Results

PLS-DA Models: Each Tumor vs All Others (*tumor histological subtype differentiation*)

#	2-Class PLS-DA Model Description	Sensitivity	Specificity	Accuracy	AUROC	# Factors
1	Clear Cell RCC (26 FOVs) vs All Others (12 FOVs)	100.0%	100.0%	100.0%	1.000	6
2	Chromophobe RCC (2 FOVs) RCC vs All Others (36 FOVs)	100.0%	100.0%	100.0%	1.000	6
3	Papillary RCC (6 FOVs) vs All Others (32 FOVs)	83.3%	90.6%	89.5%	0.896	10
4	Transitional Cell Carcinoma (4 FOVs) vs All Others (34 FOVs)	100.0%	97.1%	97.4%	0.993	5

- Model Parameters
  - PLS-DA models built comparing each tumor type with all other tumor types (grouped together as 1 class).
  - Leave-one-field-of-view-out (LO-FOVO) cross validation was performed
  - Spectral range: 520 – 1050 nm (Vis-NIR)
- Basis for Discrimination
  - Spectral peak at 975 nm, corresponding to water, most intense for ccRCC indicating hypervascularity
  - Other subtypes show hypovascularity

Allegheny Health Network

ChemImage
www.chemimage.com

Conclusion

- These positive results demonstrate the potential of MCI for augmenting a surgeon's ability to accurately visualize kidney tumors and to identify histological subtype without the use of contrast agents
- This innovative imaging modality has the capability of being applied to other forms of extirpative surgeries

- **Founding source: ChemImage corporation**

- **Corresponding author: Arash Samiei (samieia@chemimage.com)**

Allegheny Health Network

ChemImage®
www.chemimage.com