The Promising Potential of Ex Vivo Microscopy as the Next Generation Digital Microscopy Tool for Surgical Pathology Practice

IVM Webinar

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• Nationally and Internationally recognized Breast Pathologist and Cytopathologist
• Avid researcher and leading investigator for the investigation of optical imaging modalities in pathology.
• IVM Committee Member
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• Personalized cancer therapy

• Research funding from The University of Texas MD Anderson Cancer Center

• No financial interests in the products or companies covered in the webinar
Optical Imaging

Utilizes light in the visible and adjacent spectrum
Techniques for noninvasive imaging of tissues
Optical Imaging

BIOMEDICAL APPLICATIONS

- In Vivo
  - High Resolution Real Time Imaging
  - Optical Biopsy
  - Real Time Histopathology
  - Histopathology at Bedside

- Ex Vivo
Ex Vivo Tissue Optical Imaging

Optical sectioning microscopy techniques

- EVALUATION OF TISSUES REQUIRING MINIMAL OR NO TISSUE PREPARATION
- AVAILABILITY OF DIGITAL IMAGES THAT CAN BE VIEWED AT THE SITE OF PROCUREMENT OR REMOTELY
- EX VIVO TISSUE DIGITAL IMAGES CAN BE STORED, RETRIEVED AND INTEGRATED INTO ELECTRONIC MEDICAL RECORDS
- DIGITAL IMAGES AMENABLE TO MACHINE LEARNING
Ex Vivo Microscopy

POTENTIAL APPLICATIONS

Real time bedside tissue qualification of core needle biopsy, endoscopic biopsy

Intraoperative evaluation of small fragments of tissues

Intraoperative evaluation of margins of surgical resection specimens

Procuring high quality tissue for biobanking
Ex Vivo Tissue Optical Imaging

Optical Principle

- Confocal Microscopy (CM)
- Optical Coherence Tomography (OCT)
- Full-field optical coherence tomography (FF-OCT)
- Stimulated Raman Spectroscopy (SRS)
- Microscopy using Ultraviolet Surface Excitation (MUSE)
- Structured illumination microscopy (SIM)
- Light Sheet Microscopy (LSM)
- Nonlinear Microscopy (NLM)
CONFOCAL MICROSCOPE

Caliber ID Rochester NY

Histolog Scanner, SamanTree Medical SA, Switzerland
CONFOCAL MICROSCOPY

Confocal Reflectance: Tissue autofluorescence

Confocal Fluorescence: With contrast agents

785 nm

Acridine orange: 488 nm
Fluorescent agents and laser wavelengths for excitation

<table>
<thead>
<tr>
<th>Fluorescent Dye</th>
<th>Wavelength (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proflavine</td>
<td>488</td>
</tr>
<tr>
<td>Acridine Orange</td>
<td>488</td>
</tr>
<tr>
<td>Cresyl Violet</td>
<td>561</td>
</tr>
<tr>
<td>Fluorescein</td>
<td>488</td>
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<tr>
<td>Indocyanine Green</td>
<td>780</td>
</tr>
<tr>
<td>Methylene Blue</td>
<td>638</td>
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<tr>
<td>Toluidine Blue</td>
<td>638</td>
</tr>
<tr>
<td>Acriflavine Hydrochloride</td>
<td>488</td>
</tr>
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</table>
Mosaic Of Fluorescence Confocal Microscopy (FCM) Images
Fluorescence confocal microscopy (FCM) Image
Invasive Ductal Carcinoma of Breast
FLUORESCENCE CONFOCAL MICROSCOPY (FCM)

Most Frequently Used in Studies Related to Ex-Vivo Tissue Imaging

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>~ 96%</td>
<td>~ 96%</td>
</tr>
<tr>
<td>Specificity</td>
<td>~ 99%</td>
<td>~ 97%</td>
</tr>
</tbody>
</table>

Skin Specimens
Moh’s Surgery
Basal Cell Carcinoma
Diagnosis
Margin Assessment

Non-skin specimens from almost all organs
Tissue Recognition
Specific Diagnosis

Krishnamurthy S et al Archives of Pathol Lab Medicine 2018
Puliatti S et al. BJU 2019
Ex Vivo Microscopy

POTENTIAL APPLICATIONS

- Real time bedside tissue qualification of core needle biopsy, endoscopic biopsy
- Intraoperative evaluation of small fragments of tissues
- Intraoperative evaluation of margins of surgical resection specimens
- Procuring high quality tissue for biobanking
Acquisition of high quality CNB desirable in medical practice
# Immediate Assessment of CNB

## Touch Preparation

**Preferred Method**
- Simple, easy
- Can be performed at bedside
- Fast

## Frozen Section

**Not Recommended**
- Loss of tissue in cryostat
- Cannot generally be performed at bedside
- Time consuming

---

**CNB**

**Touch Prep**

**Frozen section**
IMMEDIATE ASSESSMENT OF CNB TOUCH PREPARATION OF CNB

- High level of sensitivity and specificity to indicate accurate targeting of the lesion
- Not possible to evaluate the quality of CNB with respect to tumor cellularity and suitability of the tissue for genomic testing and IHC testing
- Can cause distortion and loss of tissue with less than optimal preservation of tumor cells for final histopathological examination
CORE NEEDLE BIOPSY

IMMEDIATE ASSESSMENT OF CNB

Need for better modalities for immediate evaluation of the quality of CNB at the time of procurement

BED SIDE EVALUATION

• Guide the radiologist regarding accurate targeting
• Influence the number of CNBs to be procured
• Reduce second visits for repeat biopsy
• Immediate triaging of tissue for ancillary studies
Fluorescent Confocal Microscopy (FCM) of Breast CNB From patients with Inflammatory Breast Carcinoma

Fluorescent Confocal Microscopy (FCM) of Breast CNB from patients with Inflammatory Breast Carcinoma

**INTER-RATER AGREEMENT**

<table>
<thead>
<tr>
<th>Image type</th>
<th>Kappa coefficient</th>
<th>Standard error</th>
<th>Level of agreement</th>
<th>P value</th>
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<td>0.088</td>
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<td>Histological vs. false-colored confocal</td>
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<td>0.258</td>
<td>Fair</td>
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</table>

FCM of Invasive Ductal Carcinoma of Breast

Residual normal and tumor tissue from surgical resections

Optimize CFM platform to evaluate small fragments similar to CNB
# Fluorescence Confocal Microscopy (FCM) of Small Fragments of Normal Tissue

<table>
<thead>
<tr>
<th></th>
<th>Liver</th>
<th>Lung</th>
<th>Kidney</th>
<th>Breast</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSI</td>
<td><img src="image1" alt="Liver GSI" /></td>
<td><img src="image2" alt="Lung GSI" /></td>
<td><img src="image3" alt="Kidney GSI" /></td>
<td><img src="image4" alt="Breast GSI" /></td>
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<tr>
<td>H&amp;E</td>
<td><img src="image9" alt="Liver H&amp;E" /></td>
<td><img src="image10" alt="Lung H&amp;E" /></td>
<td><img src="image11" alt="Kidney H&amp;E" /></td>
<td><img src="image12" alt="Breast H&amp;E" /></td>
</tr>
</tbody>
</table>

Krishnamurthy S et al Archives of Pathol Lab Med 2018
Fluorescence Confocal Microscopy (FCM) of Small Fragments of Tumor Tissue

<table>
<thead>
<tr>
<th></th>
<th>Liver</th>
<th>Lung</th>
<th>Kidney</th>
<th>Breast</th>
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<tbody>
<tr>
<td>GSI</td>
<td><img src="image" alt="Liver GSI" /></td>
<td><img src="image" alt="Lung GSI" /></td>
<td><img src="image" alt="Kidney GSI" /></td>
<td><img src="image" alt="Breast GSI" /></td>
</tr>
<tr>
<td>PCI</td>
<td><img src="image" alt="Liver PCI" /></td>
<td><img src="image" alt="Lung PCI" /></td>
<td><img src="image" alt="Kidney PCI" /></td>
<td><img src="image" alt="Breast PCI" /></td>
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<tr>
<td>H&amp;E</td>
<td><img src="image" alt="Liver H&amp;E" /></td>
<td><img src="image" alt="Lung H&amp;E" /></td>
<td><img src="image" alt="Kidney H&amp;E" /></td>
<td><img src="image" alt="Breast H&amp;E" /></td>
</tr>
</tbody>
</table>

Krishnamurthy S et al Archives of Pathol Lab Medicine 2018
Fluorescence Confocal Microscopy (FCM)

<table>
<thead>
<tr>
<th>Quality of the images</th>
<th>Score</th>
<th>Description</th>
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<tbody>
<tr>
<td>1</td>
<td>20%</td>
<td>of recognizable tissue</td>
</tr>
<tr>
<td>2</td>
<td>20-50%</td>
<td>of recognizable tissue</td>
</tr>
<tr>
<td>3</td>
<td>&gt;50%</td>
<td>of recognizable tissue</td>
</tr>
</tbody>
</table>

96% tissue image of score 3

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>SENSITIVITY</td>
<td>95.5%</td>
</tr>
<tr>
<td>SPECIFICITY</td>
<td>97.3%</td>
</tr>
<tr>
<td>PPV</td>
<td>95.5%</td>
</tr>
<tr>
<td>NPV</td>
<td>97.3%</td>
</tr>
</tbody>
</table>

Even flattening of tissue for imaging can be a problem

Irregular contrast uptake resulting in dark areas

Issues do not impact overall recognition of tissue
PROSPECTIVE CLINICAL STUDY OF IR-GUIDED CNB IN REAL TIME AT THE BEDSIDE IN THE RADIOLOGY SUITE

PRIMARY OBJECTIVES

To investigate whether FCM images of IR-guided CNB can be acquired in real time at the bedside in the Radiology suite

To determine the time taken to acquire the FCM images and evaluate the quality of FCM images based on the percentage of interpretable tissue with optimal resolution

To compare the accuracy of FCM diagnoses with those of H&E stained CNB sections of the imaged tissue

Krishnamurthy S et al JAMA Network Open 2020
Each IR-guided CNB was stained with 0.6 mM Acridine orange and subjected to FCM imaging using a commercially available FCM platform (Vivascope 2500 RSG4; Caliber ID). Imaged CNB was fixed in formalin following completion of imaging, processed to generate H&E stained tissue sections. FCM images interpreted by 2 pathologists either at the site of procurement or remotely blinded to the findings in H&E sections of CNB and the diagnoses compared with H&E diagnoses.
<table>
<thead>
<tr>
<th>Source of Specimen</th>
<th>All</th>
<th>CT</th>
<th>US</th>
<th>20 Gauge</th>
<th>18 Gauge</th>
<th>14 Gauge</th>
<th>Size, Mean (SD), cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adrenal gland</td>
<td>5(4.8)</td>
<td>5(6.0)</td>
<td>0</td>
<td>0</td>
<td>5(5.7)</td>
<td>0</td>
<td>3.2(1.5)</td>
</tr>
<tr>
<td>Bone</td>
<td>8(7.6)</td>
<td>8(9.6)</td>
<td>0</td>
<td>0</td>
<td>5(5.7)</td>
<td>3(100)</td>
<td>4.0(1.7)</td>
</tr>
<tr>
<td>Kidney</td>
<td>8(7.6)</td>
<td>7(8.4)</td>
<td>1(4.5)</td>
<td>2(13.3)</td>
<td>6(6.9)</td>
<td>0</td>
<td>4.4(2.9)</td>
</tr>
<tr>
<td>Liver</td>
<td>13(12.4)</td>
<td>4(4.8)</td>
<td>9(40.9)</td>
<td>0</td>
<td>13(14.9)</td>
<td>0</td>
<td>3.4(2.9)</td>
</tr>
<tr>
<td>Lung</td>
<td>15(14.3)</td>
<td>15(18.1)</td>
<td>0</td>
<td>13(86.7)</td>
<td>2(2.3)</td>
<td>0</td>
<td>3.5(2.3)</td>
</tr>
<tr>
<td>Lymph node</td>
<td>15(14.3)</td>
<td>12(14.5)</td>
<td>3(13.6)</td>
<td>0</td>
<td>15(17.2)</td>
<td>0</td>
<td>1.9(0.9)</td>
</tr>
<tr>
<td>Pleura</td>
<td>2(1.9)</td>
<td>1(1.2)</td>
<td>1(4.5)</td>
<td>0</td>
<td>2(2.3)</td>
<td>0</td>
<td>3.0(1.4)</td>
</tr>
<tr>
<td>Soft Tissue</td>
<td>39(37.1)</td>
<td>31(37.3)</td>
<td>8(36.4)</td>
<td>0</td>
<td>39(44.8)</td>
<td>0</td>
<td>3.5(2.3)</td>
</tr>
<tr>
<td>All</td>
<td>105(100)</td>
<td>83(100)</td>
<td>22(100)</td>
<td>15(100)</td>
<td>87(100)</td>
<td>3(100)</td>
<td>3.3(2.4)</td>
</tr>
</tbody>
</table>

FCM of CNB from Liver

- Grayscale
- Pseudocolored
- H&E
FCM of CNB from Bone
FCM of CNB from soft tissue, right abdomen
FCM of CNB from Retroperitoneal lymph node
FCM of CNB from Retroperitoneal Lymph node
REAL TIME BED SIDE EVALUATION OF IR-CNBs IN THE RADIOLOGY SUITE

Acquisition of FCM images in mean of 7 minutes (3-13 min)

FCM images of optimal quality in 96.2 % cases

Tissue integrity preserved for subsequent H&E evaluation

FCM images accurately interpreted by 2 pathologists in 101/105 (96.2%)
Non-diagnostic CNBs (5/105) and CNBs with less than 20% tumor cellularity (24/105) were correctly recognized on FCM images.
# CATEGORIZATION OF FCM IMAGES BY THE TWO STUDY PATHOLOGISTS

<table>
<thead>
<tr>
<th>Category</th>
<th>Pathologist 1</th>
<th>Pathologist 2</th>
<th>Consensus</th>
<th>H&amp;E Stain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nondiagnostic</td>
<td>5(4.8)</td>
<td>5(4.8)</td>
<td>5(4.8)</td>
<td>5(4.8)</td>
</tr>
<tr>
<td>Benign or atypical</td>
<td>25(23.8)</td>
<td>28(26.7)</td>
<td>26(24.8)</td>
<td>24(22.9)</td>
</tr>
<tr>
<td>Suspicious or malignant</td>
<td>75(71.4)</td>
<td>72(68.6)</td>
<td>74(70.5)</td>
<td>76(72.4)</td>
</tr>
<tr>
<td>Total</td>
<td>105(100)</td>
<td>105(100)</td>
<td>105(100)</td>
<td>105(100)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reader</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pathologist 1</td>
<td>96.0</td>
<td>91.6</td>
<td>95.2</td>
<td>97.3</td>
<td>88.0</td>
</tr>
<tr>
<td>Pathologist 2</td>
<td>86.8</td>
<td>79.1</td>
<td>85.7</td>
<td>92.9</td>
<td>65.5</td>
</tr>
<tr>
<td>Consensus</td>
<td>97.3</td>
<td>91.6</td>
<td>96.2</td>
<td>97.3</td>
<td>91.6</td>
</tr>
</tbody>
</table>
First prospective study with consent from patients to demonstrate the utility of FCM for real time bedside evaluation of IR-guided CNBs from a variety of sites belonging to different tumor types.

The ease of acquisition of FCM images of acceptable quality and the high accuracy of diagnoses suggest that FCM can be useful for rapid evaluation of IR-guided CNBs.

Real time bedside evaluation of CNBs using FCM digital images either at the site of procurement or remotely can facilitate the acquisition of high quality CNBs in one hospital visit.

FCM is a promising next generation digital microscopy tool that can bring revolutionary changes in Surgical pathology practice.

Real time bedside tissue evaluation using next generation digital microscopy tools is a practice changer for medical practice.
Fluorescence Confocal Microscopy (FCM)

- FCM can be used for real-time tissue evaluation of small fragments of tissue: core biopsies, endoscopic biopsies and tissue fragments that are prepared as frozen sections for intraoperative evaluation.

- Margin assessment of small skin specimens such as those obtained from Moh’s surgery, small skin excisions, neurosurgical specimens, small surgical excisions can be performed.
Full-field Optical Coherence Tomography (FF-OCT)
Light CT Scanner (LLTech, Paris)

Optical acquisition unit, moving vertically: the user can control the depth of imaging

Integrated wide field camera to take sample picture before imaging

Movable X,Y stage with a sample holder

White Light Source

Joystick for X,Y,Z movements
Full-field Optical Coherence Tomography (FF-OCT)

Ex Vivo imaging of unprocessed and unlabeled tissue

Tissue measuring up to 2.0 x 2.0 cm can be imaged in 10 minutes

Several studies using FF-OCT:
- Tissues from a variety of organs: Lung, Kidney, Breast, Brain, Pancreas, skin
- Sample size: 13-100
  - Sensitivity: 72% to 94%
  - Specificity: 73% to 79%

Prostate core biopsy: 119 cores
- Sensitivity: 63%
- Specificity: 74%

Assayag O et al. TCRT Express 2013
van Manen L et al. PLOS ONE 2017
Full-field Optical Coherence Tomography (FF-OCT)

Axial resolution
1 µm

Transverse resolution
1.5 µm

Depth of penetration
200 µm to 1mm

Field of view
25 mm

LUNG ADENOCARCINOMA
Full-field Optical Coherence Tomography (FF-OCT)

METASTATIC WILM’S TUMOR
Full-field Optical Coherence Tomography (FF-OCT)

Necrotic tissue without viable cells
Full-Field Optical Coherence Tomography (FF-OCT)

FIBROSIS IN LIVER BIOPSY
Overestimation of tumor cellularity resulting from the inability to distinguish tumor from stromal fibrosis, inflammation and normal tissue or necrosis

Issues identified with the imaging platform:
• Specimen alignment for imaging
• Time taken for image acquisition
• Image resolution needs improvement
• Difficulty in distinguishing tumor from fibrosis, inflammation and necrosis
• Image contrast to increase sensitivity of interpretation
Dynamic Full-field Optical Coherence Tomography (D-FFOCT)

BREAST: DUCTAL CARCINOMA IN SITU (DCIS)

LYMPH NODE: METASTATIC ADENOCARCINOMA

Dynamic Full-field Optical Coherence Tomography (D-FFOCT)

Invasive Ductal carcinoma
Optical Coherence Tomography
OTIS (Perimeter Medical Imaging, Toronto)

Interpretation of 90 OCT image atlas by Radiologists, surgeons, pathologists

Sensitivity : 80%
Specificity : 87%
Accuracy : 87%

Ongoing prospective clinical studies

Ha R et al. Acad Radiol. 2018
Optical Coherence Tomography (OCT)

Normal Breast

Malignant Mammary tumor

Enables visualization of tissue architecture
Cellular details cannot be appreciated
Contrast arises from scattering within tissue
Image resolution: 1-15 µm
Imaging depth: 2-3 mm
Optical coherence tomography for Breast Margins (OTIS)
Optical coherence tomography with artificial intelligence tool for breast margins
Stimulated Raman Scattering Microscopy (SRS)

- Imaging based on intrinsic vibrational properties of molecules such as lipids and proteins
  
  Coherent anti-Stokes Raman scattering microscopy
  Stimulated Raman scattering microscopy

- Chemical contrast created by the vibrational properties of lipids and proteins

- Optical sectioning by nonlinear excitation

- Tissue imaging without adding extrinsic labeling agents

- Image processing to create virtual pseudocolored images resembling H&E – Stimulated Raman Scattering histology (SRH)
Stimulated Raman Scattering Microscopy (SRS)
Stimulated Raman Scattering Microscopy (SRS)

- 101 neurosurgical specimens studied in Neurosurgery operating room using a portable fibre-laser based SRS microscope
- Image processing to create images resembling H&E stimulated Raman histology (SRH)
- Virtual H&E stained slides revealing essential diagnostic features
- 92% concordance of SRH and conventional histology
- Supervised machine learning algorithm enabling automated tissue diagnosis based on quantified SRH image attributes
- Brain tumor subtypes predicted with 90% accuracy
- Study of 33 pediatric brain tumors: 96% concordance of SRH with conventional histology
- Machine learning algorithm for distinction of benign from malignant tumors: Prediction with 100% accuracy.

Orringer DA et al Nat Biomed Eng. 2017
Hollon T et al Neurosurg Focus 2016
Liver: Metastatic Adenocarcinoma from GI Primary
Stimulated Raman Scattering Microscopy (SRS)

- Effective tissue imaging using SRS microscope and acquisition of SRH images requires the tissue to be less than 25µm in thickness.

- Tissues that are soft in consistency allow good compression thereby aiding in the acquisition of good quality SRH images for interpretation.

- The commercially available SRS microscope (Invenio Imaging Inc. Santa Clara, CA) can be utilized for intraoperative diagnosis of tissues obtained from neurosurgical procedures.

- Utility of SRS microscope for non-neurosurgical specimens not yet fully investigated.
## Ex Vivo Tissue Imaging Platforms for Surgical Pathology Practice

### Commercially Available Platforms

<table>
<thead>
<tr>
<th>Optical Technique</th>
<th>Labeled</th>
<th>Un-Labeled</th>
<th>H &amp; E Like Images</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluorescence Confocal Microscopy</td>
<td>√</td>
<td>x</td>
<td>√</td>
</tr>
<tr>
<td>Dynamic Full-field Optical Coherence Tomography</td>
<td>x</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Stimulated Raman Scatterings Microscopy</td>
<td>x</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Optical Coherence Tomography</td>
<td>x</td>
<td>√</td>
<td>x</td>
</tr>
</tbody>
</table>
## Suitability of Ex Vivo Tissue Imaging Platforms for Potential Applications in Surgical Pathology Practice

### Commerically Available Platforms

<table>
<thead>
<tr>
<th>Optical Technique</th>
<th>Evaluation of Core Biopsy Endoscopic Biopsy</th>
<th>Adjunct to Intraoperative Frozen Section Analysis</th>
<th>Surgical Margin Evaluation</th>
<th>Biobanking</th>
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</thead>
<tbody>
<tr>
<td>Fluorescence Confocal Microscopy</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>X</td>
</tr>
<tr>
<td>Dynamic Full-field Optical Coherence Tomography</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>X</td>
</tr>
<tr>
<td>Stimulated Raman Scattering Microscopy</td>
<td>X</td>
<td>√ (Neuropathology specimens)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Optical Coherence Tomography</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>√</td>
</tr>
</tbody>
</table>

Moh’s Surgery/Small Excision
Non-Skin Larger Specimen

**Note:**
- √: Suitable
- X: Not suitable
Ex vivo Tissue Optical Imaging

ATTRACTION FOR UTILIZATION IN SURGICAL PATHOLOGY

ALTERNATE MODALITIES TO VISUALIZE TISSUES

RAPIDLY EVOLVING FIELD THAT CAN BRING REVOLUTIONARY CHANGES TO SURGICAL PATHOLOGY PRACTICE
Ex Vivo Microscopy

POTENTIAL APPLICATIONS

- Real time bedside tissue qualification of core needle biopsy, endoscopic biopsy
- Intraoperative evaluation of small fragments of tissues
- Intraoperative evaluation of margins of surgical resection specimens
- Procuring high quality tissue for biobanking
Ex Vivo Microscopy

Next Generation Digital Microscopy Tool

Investigational/Clinical Use

Promising Potential for Incorporation into Surgical Pathology Clinical Practice in Academic and Community Settings
Acknowledgements

Pathology
Stanley Hamilton, M.D
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For more information, go to cap.org and search for IVM Topic Center page.
The IVM resource guide highlights current IVM articles and other resources that assist in understanding and potentially adopting IVM and EVM

- Printed guides are available for members ($39) and non-members ($69)
- The digital copies of all four Resource Guides are a complimentary member benefit
- Access them [www.cap.org](http://www.cap.org) > Resources and Publications
IVM Short Presentations on Emerging Concepts (SPECs) – see handout

• **IVM SPECs are:**
  - Short PowerPoints, created for pathologists
  - Useful for educating colleagues about IVM and GI specialist on the role and value of pathologists in IVM

• **IVM SPEC Topics:**
  - In Vivo Microscopy (IVM): A New Role for Pathologists
  - IVM of the GI Tract
  - Ex Vivo Microscopy (EVM): A New Tool for Pathologists
  - Access them [www.cap.org](http://www.cap.org) > Resources and Publications
IVM Topic Center Page on CAP.ORG

- Check the IVM Topic Center for continued updates and for all your IVM resources

www.cap.org > Search for “IVM Topic Center”

In Vivo Microscopy Topic Center

Pathologists are key players in the development, validation, and clinical implementation of new microscopic imaging technologies. At the forefront is In Vivo Microscopy, where microscopic images are obtained in vivo, in real-time, during clinical procedures.

In Vivo Microscopy in Detail

In Vivo Microscopy (IVM) is an exciting field where microscopic images are obtained in vivo, in real-time, during clinical procedures. IVM imaging technologies use light and rapidly produce 2D or 3D (tomographic) microscopic images. These images may be obtained using instrumentation compatible with existing standard of care clinical instruments (e.g., that can be inserted into endoscope accessory ports) or as standalone imaging tools. IVM is in clinical use in Gastroenterology, Ophthalmology, Cardiology, Dermatology, and in other clinical disciplines, including Pulmonary Medicine, Urology, Breast, and Neurosurgery.

Contact Information

Please direct questions or comments to:

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THANK YOU!

Thank you for attending our webinar “The Promising Potential of Ex Vivo Microscopy as the Next Generation Digital Microscopy Tool for Surgical Pathology Practice” by Savitri Krishnamurthy, MD, FCAP

For comments about this webinar or suggestions for upcoming webinars, contact ivminfo@cap.org

NOTE: There is no CME/CE credit available for today’s complimentary webinar. The pdf of the presentation will be sent out in about 1 week.