An In-Depth Comparison of Two Near-Infrared Fluorescence Imaging Systems in Intracranial Tumors

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Learning Objectives

By the conclusion of this session, participants should be able to

1) Understand that options for intraoperative fluorescence imaging exist beyond the traditional surgical microscopes

2) Describe the main advantages and disadvantages of the two systems

3) Identify a system that suits their own operative workflow

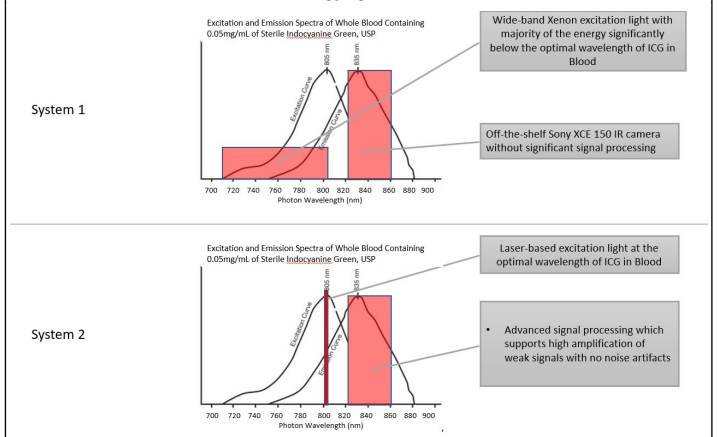
Introduction

Distinguishing neoplasm from normal brain parenchyma in real time is critical for the neurosurgeon. Near-infrared (NIR) fluorescence-guided-surgery has demonstrated superior sensitivity for detecting neoplasm intraoperatively. To prepare for the increasing number of NIR fluorophores in future molecular imaging trials, we chose to compare a state-of-the-art neurosurgical microscope outfitted with a fluorescence-detection module (System1) to one of the commercially available NIR-visualization exoscope platforms (System2).

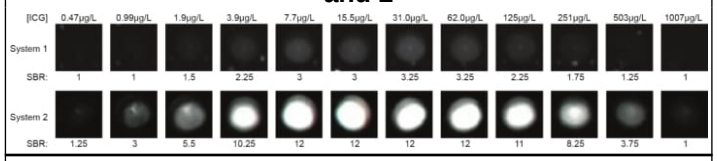
Methods

System1 had a xenon light source for excitation and a 820-860nm filter for emission. System2 had an 805nm laser light source for excitation and a camera to detect emission at 820-860nm. Serial dilutions of ICG from 0.47 – 1007μg/L were imaged with both systems under the same conditions and NIR signal for each concentration was recorded. In addition, 12 patients with intracranial tumors received 5mg/kg of intravenous ICG infusion approximately 24 hours prior to surgery. In the operating room, NIR signal-to-background-ratios (SBR) for the tumors were measured with both systems at various points along the surgery.

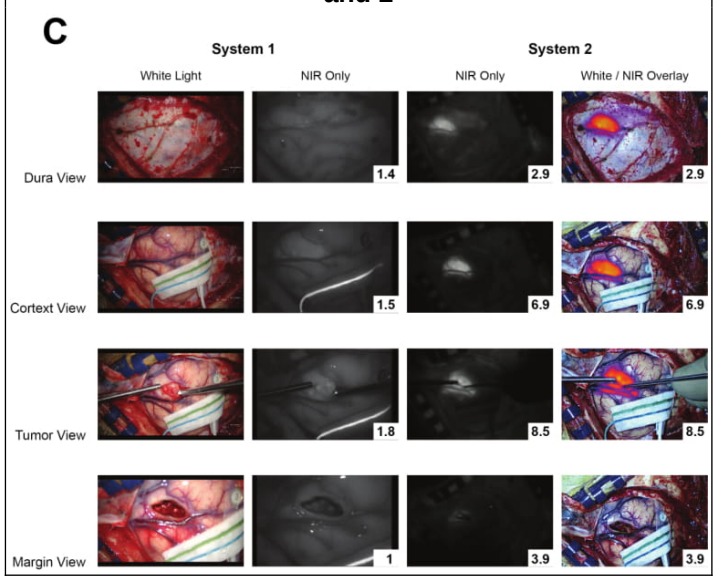
Comparison of Excitation and Emission for Systems 1 and 2



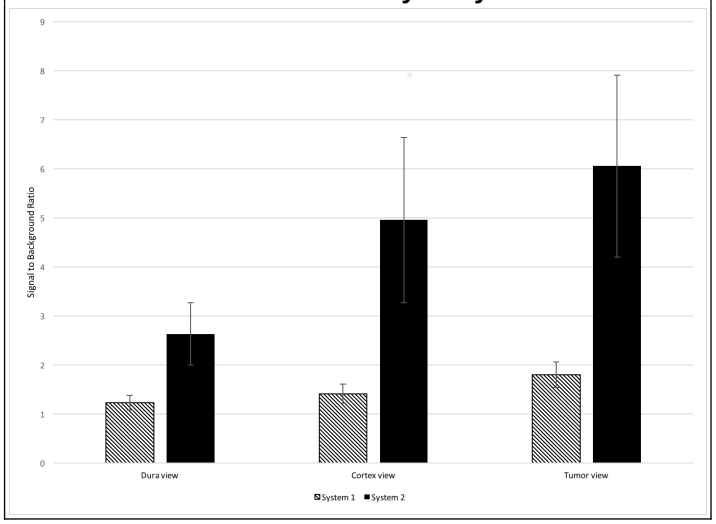
In-vitro Imaging of ICG Serial Dilutions with Systems 1 and 2



In-vivo Imaging of NIR Fluorescence with Systems 1 and 2



NIR Fluorescence Sensitivity of Systems 1 and 2



Results

In-vitro, System2 demonstrated greater ICG sensitivity (System1: 1.5–251 μg/L with maximum SBR 3.25; System2: 0.99–503μg/L with maximum SBR 12). In-vivo, 26 intraoperative NIR images were taken with System1 and 24 with System2 in 12 patients. Prior to dura opening, System1 did not reliably detect ICG fluorescence, with SBR 1.2±0.15, while System2 easily detected NIR fluorescence from the tumor with SBR 2.0±0.69 (p-value=0.0168). Similarly, after dura opening, System1 and System2 detected NIR fluorescence with SBRs of 1.4±0.23 and 4.6±1.8, respectively (p-value<0.001). Finally, with the tumor in direct line of sight, System1 and System2 detected NIR fluorescence with SBRs of 1.6±0.30 and 6.8±1.9, respectively (p-value <0.001).

Conclusion

Dedicated NIR imaging platforms can outperform conventional surgical microscopes in intraoperative NIR detection, with significantly greater sensitivity and detection range. Future microscopes that incorporate this enhanced sensitivity may enhance the use of intraoperative NIR fluorescence to detect neoplasm and improve patient outcome.