

Optical Imaging to Optimize Biopsy Site Selection

Jackson Coole¹, Ruchika Mitbander¹, David Brenes¹, Imran Vohra¹, Huayu Hou¹, Alex Kortum¹, Yubo Tang¹, Richard Schwarz¹, Jennifer Carns¹, Hawraa Badaoui², Michelle Williams², Nadarajah Vigneswaran³, Ann Gillenwater², and Rebecca Richards-Kortum¹

¹Rice University, Department of Bioengineering, Houston TX, USA, ²University of Texas M.D. Anderson Cancer Center, ³The University of Texas Health Science Center School of Dentistry

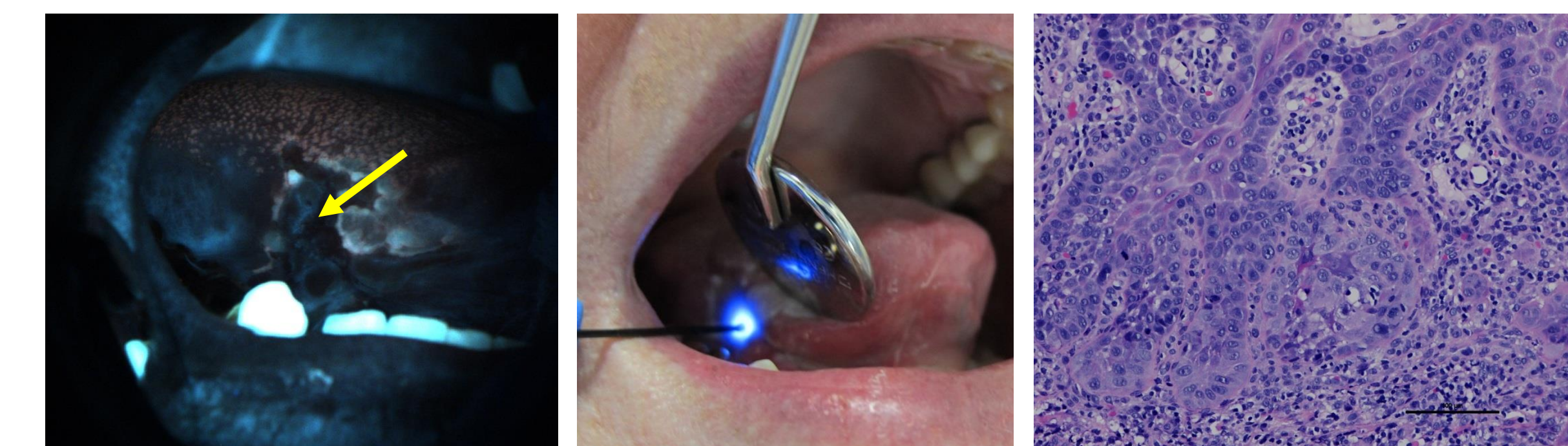
Background

Management of patients with oral potentially malignant disorders (OPMD) is extremely challenging even for experts, especially for multifocal lesions involving large areas (e.g., proliferative verrucous leukoplakia). Although dysplasia has been linked to the risk of malignant progression, pathologic diagnosis of dysplasia is limited by sampling error, relying on subjective clinical examination to choose biopsy locations. Yet, clinical and pathologic heterogeneity within oral lesions makes the decision of where to biopsy exceedingly important as a small change (1-2 mm) in biopsy location could change the diagnosis from benign to neoplastic, with dramatically different clinical consequences. Described here is a multimodal imaging system that combines autofluorescence imaging, a method shown to help clinicians identify precancerous lesions and delineate areas containing high grade dysplasia with a high sensitivity, and a high resolution fiber-optic probe designed to image superficial epithelial cells in vivo to achieve both high sensitivity and specificity.

Clinical Case



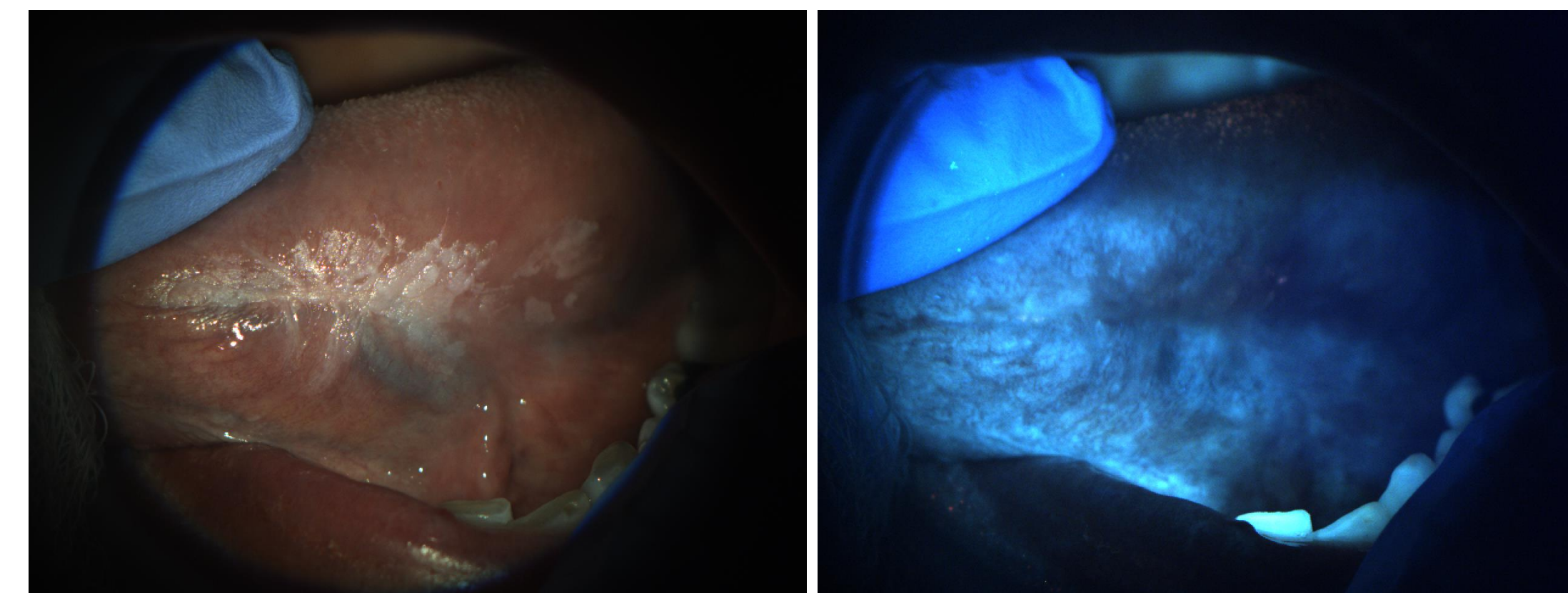
Biopsy of this ulcerated lesion on the right ventral tongue and floor of mouth had been performed at least four times during a three year period at various clinics, each showing negative results for dysplasia or carcinoma.



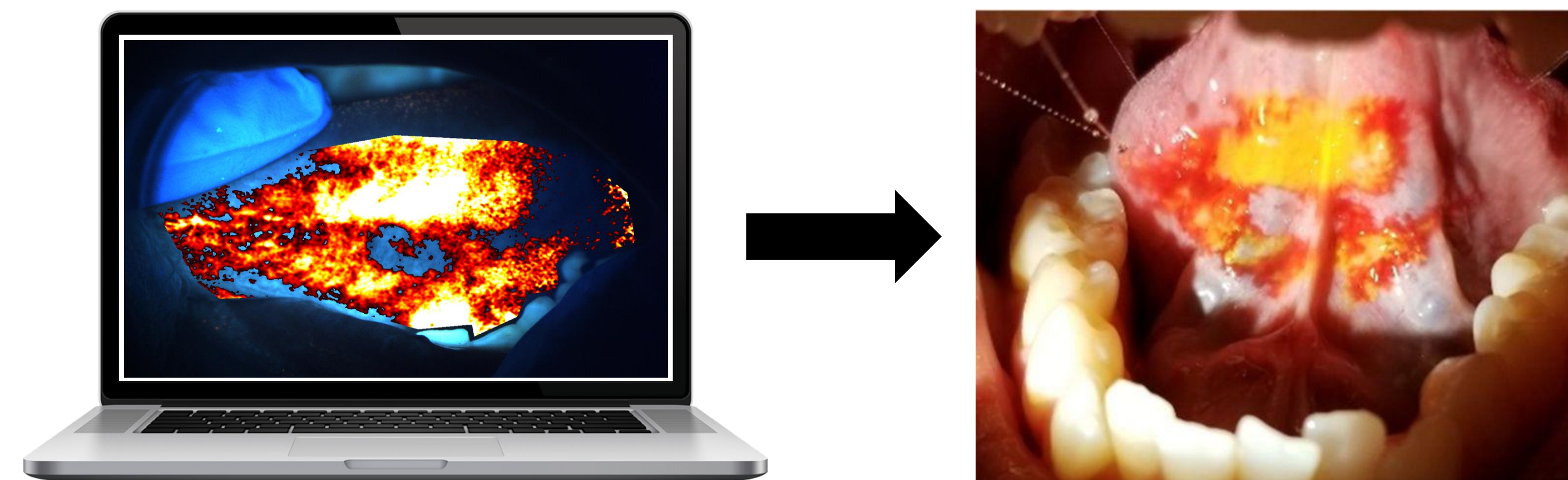
The lesion demonstrated a loss of fluorescence under blue light excitation and high resolution imaging performed at a site with a high Red / Green Ratio showed abnormal nuclei. A biopsy taken from this site revealed oral squamous cell carcinoma.

Multimodal Imaging Workflow to Aid in Representative Site Selection for Incisional Biopsy

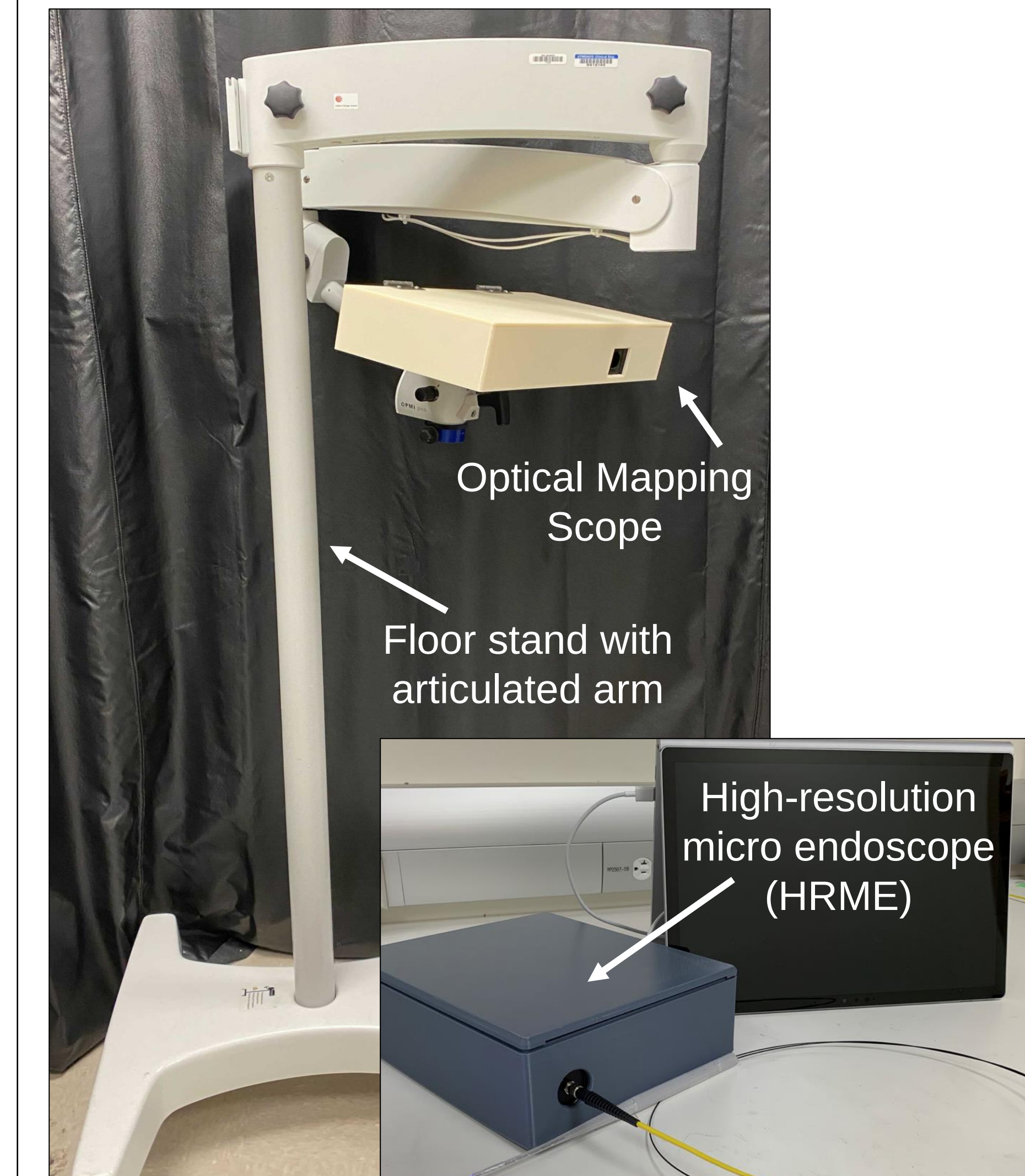
The Optical Mapping Scope (OMS) system captures and automatically analyzes widefield white light and autofluorescence images.



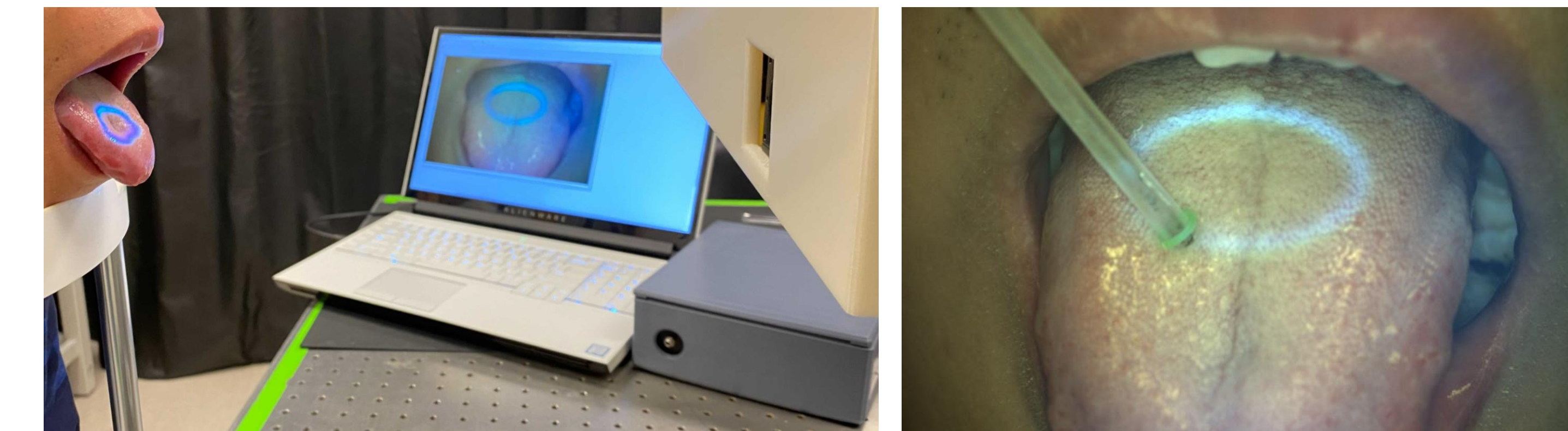
Autofluorescence images are processed on a computer to generate a map delineating areas at highest risk for dysplasia or cancer based on tissue autofluorescence. This risk map is then physically projected onto the patient's oral mucosa using digital light projection.



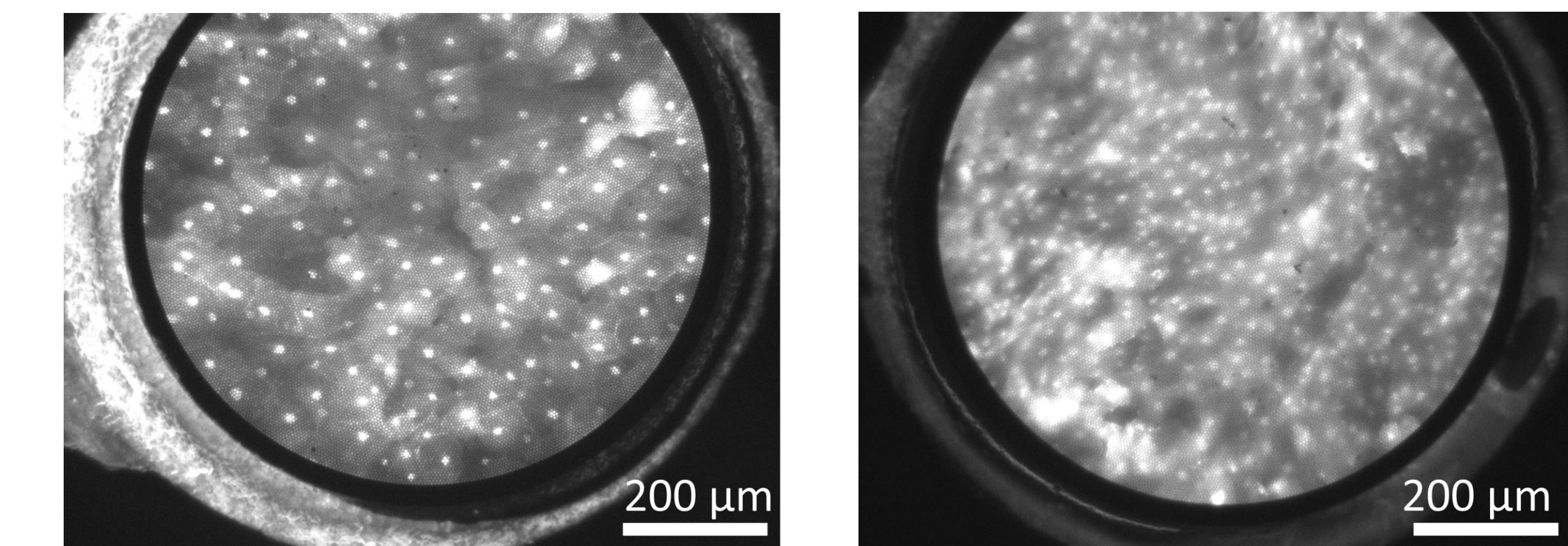
Active Biopsy Guidance System



The projected predictive risk map can be used to guide the placement of the HRME probe to collect high-frame-rate videos showing the size, shape, and distribution of epithelial cell nuclei as the probe is moved across the tissue.



HRME images from normal lesions usually exhibit small, evenly spaced nuclei, whereas HRME images from high grade lesions exhibit enlarged, crowded nuclei.



Normal Oral Mucosa

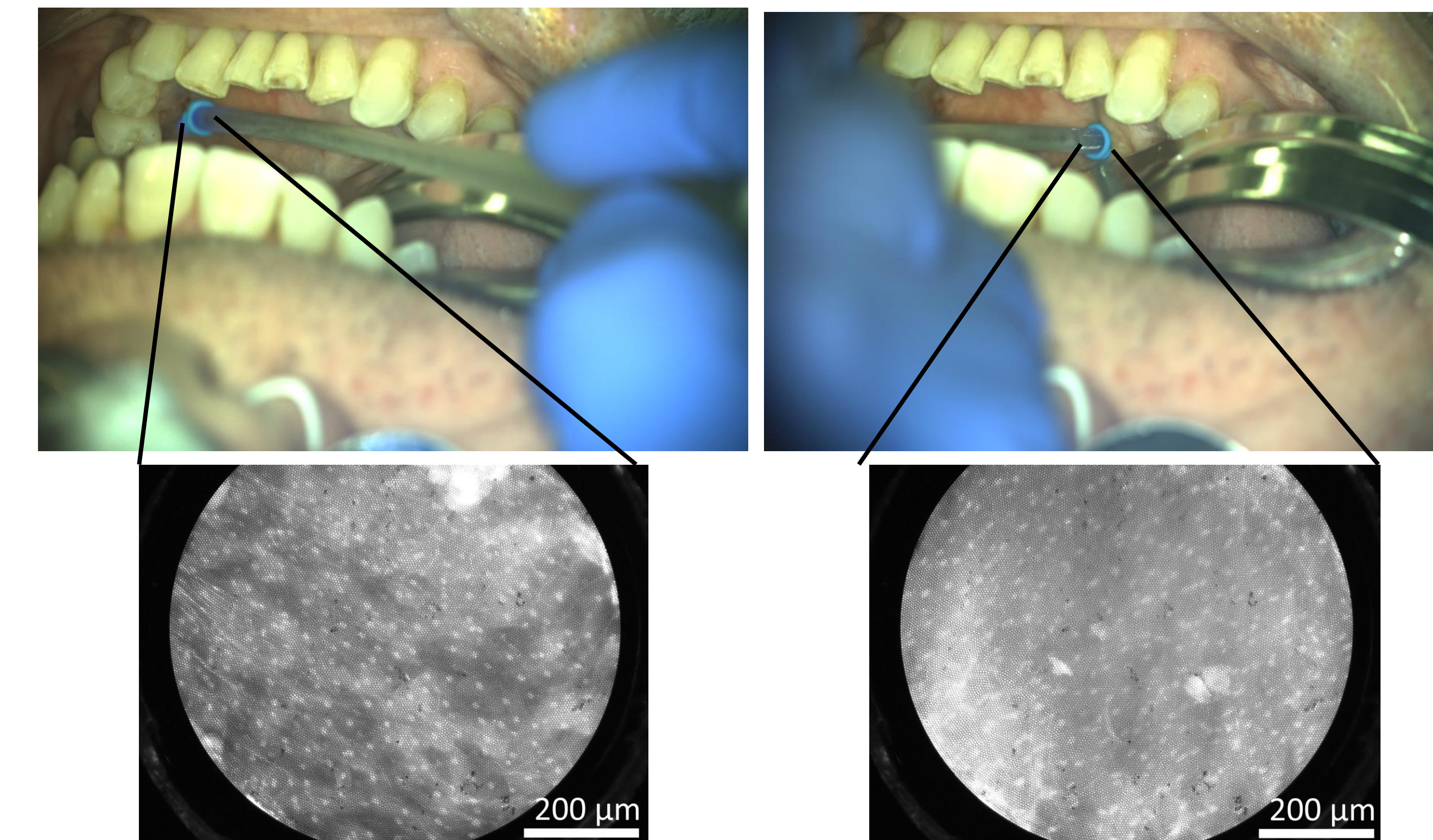
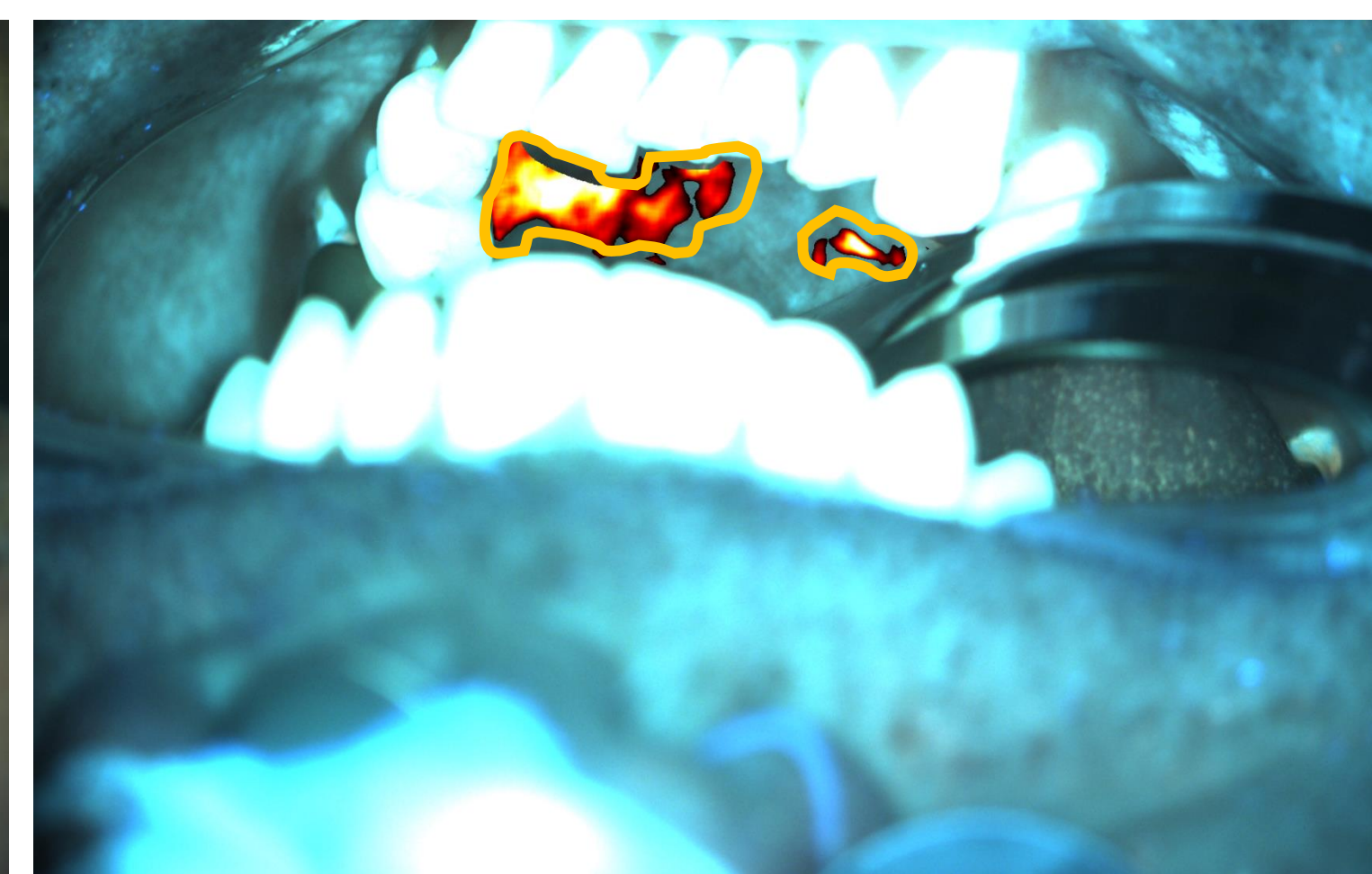
Severe Dysplasia

Preliminary Clinical Findings

Clinical Impression



Autofluorescence Risk Map Boundary



White light and autofluorescence images were acquired from the lingual mandible gingiva area. High resolution images (shown to the right) were acquired at all areas designated as suspicious by clinical impression and autofluorescence imaging. Histopathological analysis determined that the resected tissue was cancer.

Conclusions

This combination of autofluorescence and high resolution imaging modalities with direct visualization of predictive risk maps can potentially aid the clinician in the precise determination of when and where to biopsy tissue at risk for neoplasia. Further investigation is needed to determine the efficacy of this approach for improving clinicians' ability to select optimal sites for biopsy in a high risk OPMD patient population.

Acknowledgements

The authors would like to thank Yajur Maker for his assistance with the housing of the optical mapping scope. This work was supported by NIDCR RO1 DE02950.