**Title:** Photoacoustic Imaging for Breast-Conserving Surgery

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**Structured Abstract:**

Breast cancer accounts for 25% of all cancer cases among women. In fact, one in eight women will be diagnosed in their lifetime with this disease. As such, within the field of biomedical imaging, there is much interest in developing new methods of breast cancer screening, diagnosis, and treatment guidance that are non-invasive and highly sensitive. In breast-conserving surgery, which is often recommended for early stage breast cancer, the tumour(s) are excised with a thin surrounding layer of healthy tissue. In current practice, ~15% of patients require a re-excision surgery due to missed tumour tissue or insufficient margins despite the advanced intraoperative guidance and imaging techniques available. The true determination of whether a re-excision is required is by histology and requires at least 24 hours for results; we would look to provide the same information intraoperatively.

Photoacoustic imaging—which uses pulsed laser light and ultrasound detectors to acquire images—was proposed for breast imaging as early as 1994, and through the decades, various configurations of photoacoustic imaging systems have been developed. Photoacoustic imaging can achieve anatomical and functional imaging by using multiple wavelengths of light to target absorbers such as hemoglobin, lipid, or contrast agents such as indocyanine green. As such, several groups have demonstrated its use for differentiating healthy and cancerous tissue in both breast cancer and other cancers. In the past few years, our group, in parallel with two others, began investigating ex vivo imaging of tumours for the purpose of surgical guidance and tumour margin assessment in breast-conserving surgery.

Of the three groups considering this approach, Purdue University in Indiana, USA (Li et al., BOE, 2015) and the National University Hospital in Singapore (Goh et al., Clin Breast Cancer, 2018) used a multispectral approach and commercially available systems to each investigate a single human specimen. By comparison, Dr. Ivan Kosik, from our group, recently published a paper based on 52 specimens using an in-house system (Kosik et al., JBO, 2019).

Given these initial results, we began testing a new design by repurposing existing in-house detectors. Subsequently, we explored another aspect of system design (resolution vs frequency) by scanning a handheld detector array across a volume, and these results were presented last year (Yip et al., Proc of SPIE, 2019). We were also able to leverage this system to assist with validating a reporter gene (Nyström et al., Radiology: Imaging Cancer, 2019).

Finally, a system using new, custom detectors tailored for our application is nearing completion. Our ongoing work is to finish this system and apply it towards a new subset of ex vivo breast tumours. In the future, we are also exploring imaging of the human hand and wrist towards potentially diagnosing/monitoring rheumatoid arthritis and hemophilia.