Clinical feasibility of co-registered opto-acoustic and ultrasonic imaging for differentiation of breast tumors

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Principles of Opto-Acoustic Imaging

- Optical imaging provides high contrast BUT low resolution, and does not permit deep imaging.

- Ultrasound provides high resolution, BUT low contrast and provides neither quantitative molecular or functional images.

- **Solution**: Opto-acoustics (OA) provides high contrast with molecular specificity, quantitative information, and high resolution in the depth of tissue.
Optical Absorption as a Function of Laser Wavelength

Absorption Coefficient, $\mu_a$ (cm$^{-1}$)

Wavelength, nm

Absorption Coefficients for

- HbO$_2$
- Hb
- Lipids
- H$_2$O

Laser Wavelengths:

- 755 nm
- 930 nm
- 1064 nm

Graph shows absorption coefficients for different wavelengths and substances.
Image Contrast versus Depth

Optoacoustic Brightness versus Depth, mm

- 20 mm
- 40 mm
- 60 mm
- 80 mm

Noise floor
The Imagio™ System
— The Combination of OA and US —

Malignant tumor has increased blood concentration and decreased oxygenation

Benign growth has increased blood concentration and normal oxygenation

Short laser pulses

LASER 1

LASER 2
Co-registered US & OA Images
Fibroepithelial benign lesion (most likely a phyllodes tumor)

Red indicates deoxygenated hemoglobin

Imagio™ Ultrasound with Opto-acoustic Co-registration

CTRC Diagnostic Ultrasound Image

49 YO patient with new 6cm mass, superior at 1.4cm, inferior at 4.0cm, in right breast
Co-registered US & OA Images
Fibroepithelial benign lesion (most likely a phyllodes tumor)

Green indicates oxygenated hemoglobin

Imagio\textsuperscript{TM} Ultrasound with Opto-acoustic Co-registration

CTRC Diagnostic Ultrasound Image

49 YO patient with new 6cm mass, superior at 1.4cm, inferior at 4.0cm, in right breast
Co-registered US & OA Images
Fibroepithelial benign lesion (most likely a phyllodes tumor)

Combined images reveals benign tumor

49 YO patient with new 6cm mass, superior at 1.4cm, inferior at 4.0cm, in right breast
Co-registered US & OA Images
Fibroepithelial benign lesion (most likely a phyllodes tumor)

Note peak oxygenated areas in benign tumor

Imagio™ Ultrasound with Opto-acoustic Co-registration

CTRC Diagnostic Ultrasound Image

49 YO patient with new 6cm mass, superior at 1.4cm, inferior at 4.0cm, in right breast
Co-registered US & OA Images

Invasive Ductal Carcinoma

46 YO patient with new 1.5cm mass, superior at 1.7cm, inferior at 3.2 cm, in left breast.
Co-registered US & OA Images

Invasive Ductal Carcinoma

Note peak de-oxygenated area in tumor indicates cancer

Imagio™ Ultrasound with Opto-acoustic [S02] Overlay

CTRC Diagnostic Ultrasound Image

46 YO patient with new 1.5cm mass, superior at 1.7cm, inferior at 3.2 cm, in left breast.
RESULTS

- 6 tumors identified by mammography and ultrasound as suspicious for malignancy; 3 were confirmed malignant by biopsy.
- 2 out of 3 histologically benign tumors were differentiated as benign with opto-acoustics.
- 3 of 3 carcinomas were correctly identified by opto-acoustics.

Opto-acoustics correctly diagnosed 5 of the 6 lesions.

CONCLUSION

- Opto-acoustic imaging provides additional diagnostic information based on angiogenesis and blood oxygen saturation.
- These data are being used to formulate a multi-center trial.
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