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Poster

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Improved Differentiation of Breast Tumors Using Laser Opto-acoustic Ultrasonic Imaging System

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Background

This study was performed to provide preliminary clinical feasibility of a noninvasive hybrid imaging modality, Imagio, that uses combination of real-time laser opto-acoustic and ultrasound for improving diagnostic accuracy in the evaluation of breast masses. The system characterizes and differentiates breast tumors based on the concentration of blood and its oxygen saturation in the tumor angiogenesis while also showing structural information based on traditional ultrasonic imaging methods. Opto-acoustic imaging uses pulses of laser light in the near-infrared spectral range to illuminate tissues and detects the resulting pressure with arrays of ultrawide-band ultrasonic transducers. After image reconstruction, tumor location, shape and dimensions are determined with a spatial resolution of better than 1 mm.

Depth of Imaging / Sensitivity

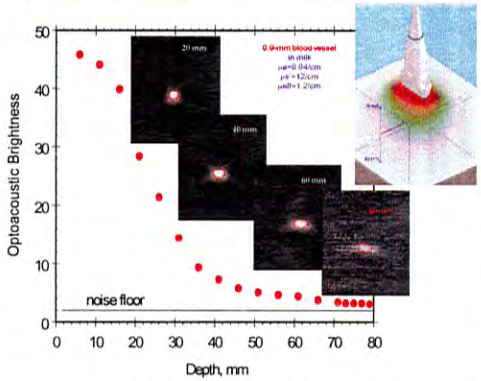

Figure 2. Cross-section OA images of a blood vessel in a milky phantom mimicking optical and acoustic properties of the breast.

Clinics: Carcinoma vs Fibroadenoma

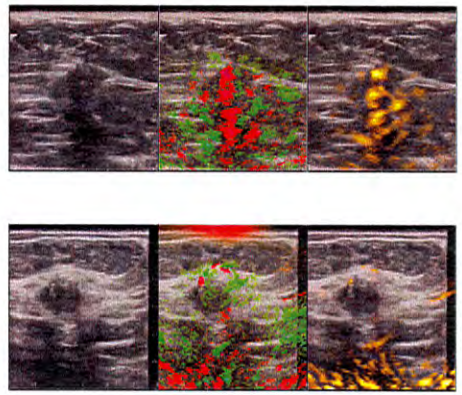

Figure 3. US/OA dual modlaity images of invasive lobular carcinoma (top) and fibroadenoma (bottom)

Discussion

After the system was calibrated in phantoms mimicking the vasculature in the breast, a feasibility study was performed on female patients with breast masses having BIRADS scores of 4 and 5 and who were scheduled for biopsy. Initial studies on 32 patients demonstrated that the combined opto-acoustic / ultrasound imaging system can detect areas of high optical absorption in the region of the tumors, confirmed with ultrasound, across varying tissue densities. Opto-acoustic maps, obtained at two different wavelengths (755 nm from Alexandrite laser and 1064 nm from Nd:YAG laser), provided information for differentiation of breast carcinomas from benign tumors based upon differences in the optical absorption of hypoxic and normally oxygenated blood in the region of the tumor.

Opto-acoustic + Ultrasonic Imaging

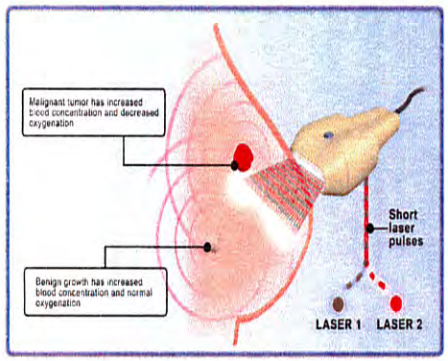

Figure 1. US+OA combines and co-registers images based on optical and acoustical contrast to improve the accuracy of cancer detection and diagnosis.

Materials & Methods

Laser illumination at the wavelength of 757 nm provides contrast based mainly on the hypoxic blood of breast carcinomas, while a wavelength of 1064 nm produces contrast dominated by the enhanced water content and normally oxygenated blood in benign fibroadenomas. Detection of the resulting ultrasonic signals with a commercial handheld ultrasound probe preserves quantitative information about the tumor optical absorption. Two opto-acoustic measurements yield solutions for the concentrations of hemoglobin and oxy-hemoglobin in pixels within the field of view. In the same location, ultrasonic images are generated to provide structure information. The optoacoustic information is displayed with the ultrasonic image to provide coregistered images containing morphological and functional information.

Optical Absorption of Hemoglobin

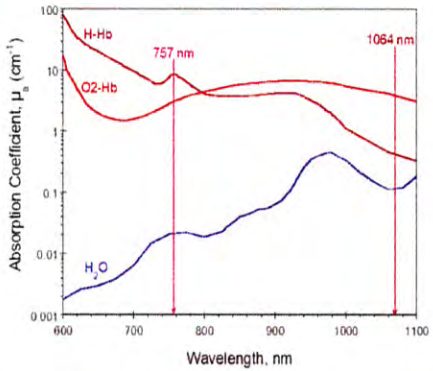

Figure 4. Optical absorption spectra of 3 major substances in tissue that contribute to opto-acoustic image brightness..

Conclusion

The combination of optically-induced functional contrast and acoustically generated high resolution anatomical imaging in a novel breast cancer imaging modality demonstrated clinical feasibility and the potential for noninvasive diagnostics. Opto-acoustic system demonstrated depth of imaging comparable with that of ultrasound. Coregistered ultrasound and opto-acoustic images provide complimentary morphologic and functional images. This new dual modality is envisioned as an adjunct to X-ray mammography that provides functional and anatomical maps.

References

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