Downclassification of Suspicious Breast Masses Using Opto-Acoustic Imaging

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Purpose

• Gray-scale ultrasound is limited in its specificity for characterization of breast masses

• Limited specificity results in false positives and negative biopsies

• Can opto-acoustic (OA) imaging increase the specificity of gray-scale ultrasound for characterization of breast masses?
Basis for Opto-Acoustic Imaging

• Cancers do not grow beyond 2-mm without developing neovascularity\(^1\)

• With angiogenesis there is increased blood flow to cancerous tissue

• Cancers are generally more metabolically active and deoxygenate hemoglobin more than benign entities or normal tissue
Opto-Acoustic Imaging

• Optical energy from a laser is absorbed and emitted acoustically\(^2,3,4\)

• Light excitation causes thermalelastic expansion within a mass which then emits a pressure (acoustic) wave that is detected by an array of acoustic sensors within a hand-held breast probe\(^5\)

• Pulses of near-infrared light at two wavelengths are applied sequentially to breast tissue
  
  • Red light (757nm) is absorbed predominantly by hypoxic (de-oxygenated) blood
  • Near-infrared light (1064 nm) is absorbed predominantly by normally oxygenated blood
Investigational Device - Imagio®

• Hand-held linear probe which can perform both gray-scale ultrasound as well emits optical pulses via a class 3b laser

• Dual wavelength optical pulses generate the OA images

• Ultrasound images are acquired and temporally interleaved and co-registered with the OA images in real-time
Opto-Acoustic Imaging: Fusion Imaging

- Fusion of laser optic imaging and gray-scale imaging in real-time^{6-12}
  - Optics – high contrast resolution (about 20/1)
  - Ultrasound – high spatial resolution and better penetration

- Fusion of anatomy and function
  - Anatomy – gray-scale ultrasound anatomy as well as OA demonstration of tumor angiogenesis
  - Function – OA demonstration of relative degrees of oxygenation/deoxygenation
Opto-Acoustic (OA) and Ultrasound Images
Real Time Hemoglobin Map

Malignant
more deoxygenated hemoglobin

Benign
more oxygenated or absent hemoglobin

Oxy
De-oxy
Opto-Acoustics (OA) 6-on-1 Real Time Display
1 gray scale map and 5 OA maps are complementary to each other
Invasive ductal carcinoma, grade II
PIONEER-01 Pilot Study

• A Pivotal Study of Imaging with Optoacoustics to diagnose breast masses detected by mammography and/or clinical findings: A New Evaluation Tool for Radiologists

• Pilot study of 100 patients was evaluated for the potential ability of OA to downgrade BI-RADS scores in benign masses

• Can BI-RADS (BR) 4a or 4b masses be downgraded to either BI-RADS 3 or 2 with OA?

• Can masses coded BI-RADS 3 be downgraded to BI-RADS 2 with OA?
PIONEER-1 Investigator Sites

- Northwestern Medicine
- Yale University School of Medicine
- New York Presbyterian Hospital
- Georgetown University Hospital
- Cleveland Clinic
- The University of Texas MD Anderson Cancer Center
- The University of Texas Health Science Center at San Antonio
- Elizabeth Wende Breast Care
- Invision Sally Jobe
- Weinstein Imaging Associates
- Boca Raton Regional Hospital
- Radnet, Inc.
- Austin Radiological Association
- Solis Women’s Health (Texas and North Carolina)
- Breast Care Specialists
Materials and Methods

• 6 of the 16 sites contributed to the pilot cases

• Women referred for diagnostic breast ultrasound due to a palpable mass or a suspicious mammographic finding

• Patients with BI-RADS 3, 4a, 4b, 4c and 5 lesions at conventional diagnostic ultrasound (CDU) were eligible for the study

• Investigators obtained gray-scale images with the Imagio® device, the internal ultrasound control (IUC), immediately before acquiring the OA images
Materials and Methods

• Independent readers (IRs) blinded to clinical data, site imaging and pathology

• 7 IRs were trained by expert reader to identify and score three OA internal features and two OA external features for each mass

• IRs offered the results of two nomograms (that were calculated from their OA feature scores) to help predict the Probability of Malignancy (POM)

• 2% or less POM $\rightarrow$ downgrade to BI-RADS 3

• 0% POM $\rightarrow$ downgrade mass to BI-RADS 2
Materials and Methods

• 102 masses from the 100 pilot study cases
• 75 biopsied masses (39 benign, 36 malignant)
• BI-RADS classification by site radiologists of conventional diagnostic ultrasound:
  4 BI-RADS 3
  18 BI-RADS 4a
  18 BI-RADS 4b
  12 BI-RADS 4c
  23 BI-RADS 5
Case #1

9-mm mass in left breast at 3:00 7 cm from the nipple

- CDU: BI-RADS 4B
- IUC: BI-RADS 4B
OA
FIBROADENOMA

9-mm mass in left breast at 3:00 7 cm from the nipple

- CDU: BI-RADS 4B
- IUC: BI-RADS 4B
- OA: BI-RADS 3
Case #2

7-mm mass in the right breast at 10:30 8 cm from the nipple

• CDU BI-RADS: 3

• IUC BI-RADS: 3
FIBROADENOMA

7-mm mass in the right breast at 10:30 8 cm from the nipple

- CDU BI-RADS 3
- IUC BI-RADS 3
- OA: BI-RADS 2

ARAD

RAD
Results

• Using OA the IRs had 97.6% sensitivity and 44.4% specificity

• Net absolute gain in specificity of 13%
Results

• Using OA, the IRs were able to downgrade site-CDU masses as follows:
  • BR 4a masses to BR 3 or 2 in 53% of cases
  • BR 4b masses to BR 3 or 2 in 33% of cases
  • BR 3 masses to BR 2 in 33% of cases

• Using OA, the IRs downgraded IUC-classified masses as follows:
  • BR 4a to either BR 3 or 2 in 43% of cases
  • BR 4b masses to either BR 3 or 2 in 13% of cases
  • BR 3 masses to BR 2 in 43% of cases
Conclusions

• Benign masses classified as BR 3, 4a and 4b could be downgraded to BR 3 or 2 by using OA with the aid of nomograms

• The use of OA could potentially decrease false positives and decrease negative biopsies

• The larger 1997 subject 16 center pivotal study will allow for confirmation
References


References


Northwestern Medicine
References


Thank You
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