Intraoperative in vivo reflectance spectroscopy for discrimination of normal, benign, and malignant breast tissues

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Hypothesis

• Optical spectroscopy is a technique that provides real-time discrimination of malignant breast tissues. This methodology can be used for:
  • Assisting core-needle biopsy
  • Intraoperative tumor margin assessment
  • Monitoring tumor response to therapy
  • The purpose of this study is to measure the optical signatures of normal and malignant breast in vivo.

Optical Signals Can Probe...

Absorption
  • Hemoglobin saturation, vascularity
  • Water content
  • Lipid content
  • Cellular metabolism
  • Structural protein content
  • Amino acids
  • Size and density of scattering centers

Fluorescence

Scattering

Data Analysis

• Parameters extracted from tissue spectra: Scattering coefficient, concentrations of oxy- and deoxyhemoglobin, beta-carotene, lymphazurin

• Enrollment / Sample Statistics

<table>
<thead>
<tr>
<th>Patients enrolled</th>
<th>32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Useable data</td>
<td>30 patients</td>
</tr>
<tr>
<td>Median age (range)</td>
<td>52 (36-74) yrs.</td>
</tr>
<tr>
<td>Mean breast density (Scale: 1-4)</td>
<td>2.7 ± 0.75</td>
</tr>
<tr>
<td>Chemotherapy Status</td>
<td>8 w/prior chemo, 22 w/o chemo</td>
</tr>
<tr>
<td>Menopausal Status</td>
<td>13 pre-, 17 post-</td>
</tr>
<tr>
<td>Tissue Breakdown (63 of 97 samples retained for analysis)</td>
<td>35 normal, 16 benign, 11 IDC, 3 ILC, 2 DCIS</td>
</tr>
</tbody>
</table>

Methods

• Intraoperative Procedure
  1. Incision made in skin of the breast
  2. Ultrasound used to guide needle-biopsy cannula to site of interest
  3. Needle is retracted, and probe inserted through cannula to interface with tissue
  4. Optical measurement made
  5. Probe retracted, and vacuum assisted biopsy of interrogated tissue made through cannula
  6. On average, 3 tissue sites interrogated per patient
  7. Biopsied tissues histopathologically analyzed for concordance analysis

• Data Analysis

  - Classification accuracy
  - Linear Discriminant Analysis

  - Cross validation
  - Key variables

  - Parameters extracted from tissue spectra: Scattering coefficient, concentrations of oxy- and deoxyhemoglobin, beta-carotene, lymphazurin

Results

• Representative Spectra

  - Adipose
    - Hemoglobin saturation: 95.6%
    - Mean Scattering Coefficient: 6.32 cm^-1

  - Invasive Ductal Carcinoma
    - Hemoglobin saturation: 42.2%
    - Mean Scattering Coefficient: 7.9 cm^-1

• Representative Extracted Optical Properties

• Discriminatory variables, Cancer (n=16) vs Non-cancer (n=41)

Conclusions and Future Work

• Diffuse reflectance spectroscopy can discriminate between malignant and non-malignant tissues on the basis of extracted physiological parameters.

  - More robust classification algorithm expected with more malignant samples (larger balanced training set)
  - Future work will include assessing utility of optical spectroscopy in early monitoring of neo-adjuvant chemotherapy

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