Multi-energy “color” X-ray
A new technique for enhanced Radiological-Pathological correlation in Breast Cancer

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Introduction

- Breast cancer develops in a genetically predisposed malformed breast lobe

- Breast cancer is widespread and multifocal in the majority of cases regardless of the size of the largest invasive component

- Multifocality and disease extent are independent prognostic factors not addressed by the TNM classification

- Large-format histological sections are currently considered the only optimal tool for pathological evaluation of a breast cancer resection specimen

Lindquist et al, Pathol Res Int, 2011
Tot et al, Hum Pathol, 2011
Large vs conventional histological slide

**PRO**
- Optimal tumor size evaluation
- Radio-Patho tumor correlation
  - Multifocality
  - Extent
  - Margin assessment

**CONTRA**
- Technical limitation (size, distortion)
- Increased cost
  - 25% consumables
  - 50% personnel time
- Non-standard format
  - Storage problem
  - Microscope fitting problem

*Tibor Tot, The Breast, 2010*
3-exposure color X-ray

Specimen X-ray

X-Ray Source

22kVp

DX

B.Dierickx et al, IISW, Hakodate, 2011
B.Dierickx et al, BHPA symposium, Brussels, 2010
3-exposure color X-ray

Specimen X-ray

X-Ray Source

22kVp

30kVp

DX

B. Dierickx et al, IISW, Hakodate, 2011
B. Dierickx et al, BHPA symposium, Brussels, 2010
3-exposure color X-ray

Compensation of absorption (inverse Beer’s law)

Luminance = average

Specimen X-ray

X-Ray Source

22kVp  30kVp  40kVp

B.Dierickx et al, IISW, Hakodate, 2011
B.Dierickx et al, BHPA symposium, Brussels, 2010
3-exposure color X-ray

Specimen X-ray

X-Ray Source

22kVp  30kVp  40kVp

Compensation of absorption (inverse Beer’s law)

Luminance = average

Chrominance = differences

empirical white balance
Oxygen/Carbon ratio codes as magenta/green or red/green/blue

B.Dierickx et al, IISW, Hakodate, 2011
B.Dierickx et al, BHPA symposium, Brussels, 2010
Material and methods

● **Specimen**
  → 38 breast resection specimens / 35 cancer
  → Conventional gross slicing 1cm thickness

● **Multi-energy specimen ‘color’ X-ray**
  → Identification of tumor
  → Tumor size
  → Tumor bed extension
  → Tumor multifocality
  → Tissue heterogeneity: necrosis, calcifications, bleeding

● **Radio-pathological correlation**
  → Conventional histopathological report (8-12 small blocks/slides)
  → Mapping color X-ray by large- and normal format histopathology
  → Correlation of tumor extent and node involvement
Original diagnosis: pT1c Unifocal

Large format slide: pT2 Unifocal
Original diagnosis:

pT1c, Unifocal, Limited
Original diagnosis:
pT1c, Unifocal, Limited

pT1c
Multifocal
Extensive

'Color' X-ray

1 cm
Example 2

Specimen X-ray

‘Color’ X-ray
pT2 Multifocal Extensive
Tumor heterogeneity and calcifications
### Assessment of multifocality and disease extent

<table>
<thead>
<tr>
<th></th>
<th>Primary pathology report</th>
<th>Conventional X-ray (pathologically confirmed)</th>
<th>‘Color’X-ray (pathologically confirmed)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Multifocal</strong></td>
<td>6/35 (17%)</td>
<td>8/35</td>
<td>12/35 (35%)</td>
<td>0.001*</td>
</tr>
<tr>
<td><strong>Extensive disease (&gt; 4 cm²)</strong></td>
<td>7/35 (20%)</td>
<td>10/35</td>
<td>15/35 (43%)</td>
<td>0.04</td>
</tr>
</tbody>
</table>

*p-value calculated on all tumor foci*
## Results

### Assessment of tumor size and pT-stage

<table>
<thead>
<tr>
<th></th>
<th>Primary pathology report</th>
<th>‘Color’ X-ray (pathologically confirmed)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size (mm)</strong></td>
<td>10.75 (mean) 10.75 (mean)</td>
<td>19.6 (mean) 19.6 (mean)</td>
<td>0.01</td>
</tr>
<tr>
<td>Largest invasive focus</td>
<td>3-50 (range) 3-50 (range)</td>
<td>8-100 (range) 8-100 (range)</td>
<td></td>
</tr>
<tr>
<td><strong>pT-stage</strong></td>
<td>T1a 1</td>
<td>T1a 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T1b 2</td>
<td>T1b 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T1c 13</td>
<td>T1c 9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T2 20</td>
<td>T2: 23</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T3 : 0</td>
<td>T3: 2</td>
<td></td>
</tr>
</tbody>
</table>
Results

Correlation between tumor extension and node status

- Extensive N+
- Limited N+
- Limited Nitc
- Extensive N0
- Limited N0

Conventional histology vs. Color X-ray, histologically confirmed
Conclusions

‘Color’ X-ray specimen mammography

- detects tumor, heterogeneity, calcifications
- multifocal tumor spots
- tumor extension

- is a promising tool to assess tumor complexity
- may be an adjunct or replacement to large-format histological slides for radio-pathological breast cancer correlation
Thank you!

- Caeleste
  Bart Dierickx

- UZBRUSSEL
  Radiology
  Nico Buls
  Inneke Willekens
  Cathérine Breucq
  Ann Schietecatte
  Johan Demey

  Pathology
  Jan Sadones
  Vanessa Ghislain
  Annitta Vleminckx