Emerging Role of Tomosynthesis in Breast Imaging

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Limitations of Mammography

- If 100 women with breast CA are screened:
  - 68 CA will be detected by mammo (85% of detected cancers)
  - 12 will be detected by CBE (15% of detected cancers)
  - 20 will occur as interval cancers in the following year

Kopans. Lancet 1999; 354:2096

Prior Improvements in Mammographic Screening

- Improved high-speed screen film techniques
- CAD
- Digital (FFDM)
- Tomosynthesis

Tomosynthesis Acquisition

- X-ray tube moves in an arc across the breast
- Series of low dose projection images are acquired at different angles
- Total dose similar to single view breast exam

Radiation Dose

- Dose (50/50 4.5 cm breast)
- MQSA = 3 mGy
- 2D~ 1.2 mGy (Tungsten)
- 3D~1.45 mGy
- Combo ~2.65 mGy
- Selenia FFDM ~1.6 mGy (Molybdenum)
- Screen/Film (ACRIN ~2.0 mGy average)

Tomosynthesis Reconstruction

Appropriate shifting and adding of raw data reinforces objects at specific height

Height 1 + Height 2 =
3D Acquisition Output

Tomo-Planes (0.5 to 1 mm)

Slabs (1 cm thick, 5mm overlap)

Z-resolution: artifact spread

- Artifact spread in z-direction depends on tomo angle and reconstruction algorithm
- «Slice thickness» determined by progressive blurring of out-of-plane structures
- Actual thickness undefined

Slabbing the volume

✓ There is no «slice thickness» in DBT, only tomo planes
✓ What people usually call «thickness» is the distance between adjacent planes
✓ Here such distance is 0.5 mm

TOMO PLANES

Slabs

✓ Slabs have thickness
✓ 1 cm (0.5 cm overlapping)

TOMOSYNTHESIS: POTENTIAL ADVANTAGES

- Increased lesion visibility (sensitivity)
- Facilitation of margin analysis
  - Tomosynthesis still based on morphology
- Reduction in recall rate through minimizing the effects of summation artifact
- Precise lesion localization

Digital Tomosynthesis

- The major limitation to the sensitivity of screening mammography is the density of breast tissue and cancers being obscured by overlapping structures.
- 10% call-back rate. As many as 25% of women recalled from mammographic screening for additional evaluation ultimately prove to have superimposed normal structures accounting for the possible abnormality ("summation shadow").
**Increased Sensitivity**

**DBT: Increased Sensitivity**

<table>
<thead>
<tr>
<th>Study</th>
<th>MG</th>
<th>MG + DBT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skaane et al, 2013</td>
<td>6.1/1000</td>
<td>8.0/1000</td>
</tr>
<tr>
<td>Ciatto et al, 2013</td>
<td>5.3/1000</td>
<td>8.1/1000</td>
</tr>
<tr>
<td>Haas et al, 2013</td>
<td>5.2/1000</td>
<td>5.7/1000</td>
</tr>
<tr>
<td>Friedwald et al, 2014</td>
<td>4.2/1000</td>
<td>5.4/1000</td>
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</table>

**Standard FFDM**

**Tomo**

**7: Improved Detection – Standard FFDM**
2: Reduction in Recalls – Standard FFDM

DBT: Increased Specificity

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<tr>
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<th>MG</th>
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<th>Difference</th>
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<tr>
<td>Skaane et al, 2013</td>
<td>61/1000</td>
<td>53/1000</td>
<td>-13%</td>
</tr>
<tr>
<td>Ciatto et al, 2013</td>
<td>62/1000</td>
<td>51/1000</td>
<td>-17%</td>
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<tr>
<td>Haas et al, 2013</td>
<td>12/1000</td>
<td>8.4/1000</td>
<td>-30%</td>
</tr>
<tr>
<td>Friedewald et al, 2014</td>
<td>107/1000</td>
<td>91/1000</td>
<td>-15%</td>
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</table>
Reduction in Call backs

Tomosynthesis: Challenges

• Image storage:
  – Data for each slice comparable to 2D MG
  – 1 GB of data for 4-view DBT examination

• Workstation readout:
  – Doubling of interpretation time

• Biopsy of tomo only findings

DBT exam size

The exam size will vary with:

- Breast size
- Weather the planes are 0.5 or 1 mm distance
- What objects are archived
- Data compression efficiency

If we consider by way of example:

- 44 mm thick breast
- An exam composed of 2 conventional 2D and 2 3D tomosynthesis acquisition
- Storage of 2D conventional for presentation images, tomosynthesis projections and volumes
- Uncompressed

<table>
<thead>
<tr>
<th>Plane Distance</th>
<th>Total Exam size</th>
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<tr>
<td>0.5 mm</td>
<td>1358 MB</td>
</tr>
<tr>
<td>1 mm</td>
<td>878 MB</td>
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</tbody>
</table>

Each image (44 mm thick breast)

<table>
<thead>
<tr>
<th>Date/time</th>
<th>Images</th>
<th>Images of 2D projections</th>
<th>Slabs</th>
<th>Plane sizes</th>
<th>Total size</th>
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</thead>
<tbody>
<tr>
<td>10:45:00</td>
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<td>274,752</td>
<td>96,354</td>
<td>484,244,49,36,20</td>
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</table>

One Exam

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C View

• 2D images generated from the tomosynthesis data
  – Eliminates the need for additional 2D exposures

• FDA approved in 2013
  – 2D still performed because no billing code for DBT

• Software cost $40,000
DBT Guided Biopsy

Clinical Application of DBT
- Screening
- Diagnostic
- Benefits:
  - Improved detection
  - Reduced recalls
  - Lesion localization
  - Margin analysis

Case: False Negative Tomo
Conclusions

- DBT is little better than FFDM with and increase cancer detection of ~ 1.5 extra CA/1000 and 15-20% reduction in recalls and is slowly becoming the standard
- DBT does not replace supplemental screening in women with dense tissue