A FROC study on the influence of breast thickness on simulated lesion detection

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Ghent – Leuven (Belgium)
Best wishes also from the Leuven team to all of you!
Incidence of breast cancer

- Belgium: 35.3% of all cancers
- Survival rate linked to cancer stage
  - 99.4% stage 1
  - 28% stage IV

Early detection

Screening

- Belgian Legislation
“False negatives—False negatives occur when mammograms appear normal even though breast cancer is present. Overall, screening mammograms miss up to 30 percent of the breast cancers that are present at the time of screening...”

Mammography AEC modes are generally set up to maintain a constant signal within the detector.
Theoretical detectability index, SDNR, under standard AEC mode decreases with thickness.

Is lesion detectability in patients decreasing too?
Objective

- Create database of models of a set of specific lesions
  - Masses
  - Clusters of microcalcifications
- Define groups of images for comparative studies
- Create the groups of images
- Simulate all the lesions in the different groups for comparative measurements
- Free search experiment by radiologists
Creation of a reference experiment...
in the Leuven way

Setting the gold standard since gold was the standard.

Toronto, 2003
How the study was performed

START

3D models

Physically corrected templates

Raw image

Processed image

Detectability score

Statistical analysis

FINISH
Screening patients
- 520 Cranio-Caudal mammograms
- Inclusion criteria: absence of lesions

4 compressed breast thickness groups
- T1<=29mm; T2 = 30-49mm; T3 = 50-69mm; T4>=70mm

130 images per thickness group
- 70 with one inserted simulated lesion
- 60 normal

35 different mass models
35 different µcalcification clusters
Image characterization

- Normal mammograms
  - Verified by radiologist
- Glandularity score (Volpara)
- BIRADS score (by the radiologist)

- Every lesion is inserted in a fully characterized image;
- The lesion is re-inserted in a matching image of another group
Simulated lesions

3D models

Templates: 2D projections

Central core
Large spicules
Thin spicules
µcalcification cluster

Lesion insertion

- BI-RADS score
- Volpara local glandularity value

4 mammograms of BIRADS 2 selected for insertion of a mass in a Volpara local glandularity area of 21%
Example

Before Insertion

After Insertion

Compressed Breast Thickness
Observer study

- Study on Siemens Mammomat Inspiration
- Siemens OpView2 processing
- Viewer software: ViewDEX*
- Free- response receiver operating characteristic (FROC) study
- 4 radiologists
- Jackknife-alternative free-response receiver (JAFROC) analysis°
  - Alternative free- response receiver operating characteristic area (AFROC)
  - P-value

° JAFROC, version 4.2.1, D.P. Chakraborty; available from http://www.devchakraborty.com
## Results: correct lesions scored

<table>
<thead>
<tr>
<th></th>
<th>Correct lesions marked/total lesions</th>
<th>Correct microcalcification clusters marked/total microcalcification clusters</th>
<th>Correct masses marked/total masses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Default AEC settings</strong></td>
<td></td>
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<tr>
<td><strong>T1 (≤29 mm)</strong></td>
<td>197/280 (70%)</td>
<td>86/140 (61%)</td>
<td>111/140 (79%)</td>
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<tr>
<td><strong>T2 (30-49 mm)</strong></td>
<td>144/280 (50%)</td>
<td>81/140 (58%)</td>
<td>63/140 (45%)</td>
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<tr>
<td><strong>T3 (50-69 mm)</strong></td>
<td>94/280 (34%)</td>
<td>45/140 (32%)</td>
<td>49/140 (35%)</td>
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<tr>
<td><strong>T4 (≥70mm)</strong></td>
<td>104/280 (37%)</td>
<td>37/140 (26%)</td>
<td>67/140 (48%)</td>
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## AFROC area, all lesions

P-value >0.05 statistically different

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**AFROC area, μcalcification clusters**

**P-value >0.05 statistically different**

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μcalcification are quantum noise limited

Increasing breast thickness, increases scatter in the breast with signal within the detector constant
AFROC area, masses

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masses are structured noise limited
Microcalcification cluster

Default AEC mode

T1 = 28 mm  T2 = 49 mm  T3 = 64 mm  T4 = 83 mm
Conclusions

For the current mammographic AEC set-up:

- the same lesion is less detectable in a thicker breast (same BIRADS, same glandularity)
- decreasing lesion detectability with increasing thickness
- larger impact on μcalcifications
- smaller on masses

Impact for screening ‘to be determined’

- Influenced by texture more than by glandularity?
- Fraction of subtle lesions...
Subsequent study....
Measurement/calculation of detectability constant setting
Results with a message

(a) Validation - All lesions
(b) Validation - microcalcification clusters
(c) Validation - Masses
Future applications

- Re-read the same images on a better display
- Simulate the same lesions in gridless 2D mammography (Siemens Inspiration PRIME)
- Simulate the same lesions in breast tomosynthesis
- ...
Acknowledgement

- The team of medical physicists & radiologists & radiographers in Leuven
- The mammography team in Siemens Erlangen

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- COMADIS project of IWT, Belgium