Mammographic density estimation: one-to-one comparison between digital mammography and digital breast tomosynthesis using a fully automated software

Poster No.: C-0474
Congress: ECR 2012
Type: Scientific Exhibit
Authors: S. Airaldi¹, P. Cambiaso¹, M. Calabrese¹, A. Tagliafico², F. Monetti¹, G. Tagliafico¹, ¹Genova/IT, ²Genoa/IT
Keywords: Comparative studies, Mammography, Breast, Epidemiology, Volvulus
DOI: 10.1594/ecr2012/C-0474

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Purpose

To compare breast density on full-field digital mammography (FFDM) and digital breast tomosynthesis using fully automated software.
Fig. 4: Example of software interface.

© - Genova/IT
Methods and Materials

The study was approved by the local ethics committee (National Institute for Cancer Research) and written informed consent was obtained from all participating women.

Patients

This was a prospective study of diagnostic women that started in March 2010 and ended in June 2010. Both DBT and FFDM images were obtained in the participating women. After DBT and FFDM, further work-up was done when indicated.

Digital Mammography

For digital mammography, the breast was positioned for mediolateral oblique and craniocaudal views and was compressed by using the standard mammographic compression force (mean, 11 daN; range, 3-20 daN). Each mammographic projection was acquired with a spatial resolution of 100 m/pixel by using a detector with a 23- × 19-cm² field of view, corresponding to a 2304- × 1920-pixel image size. After acquisition, digital mammograms were available in an unprocessed, raw format, with pixel values linearly proportional to the X-ray exposure at the detector, as well as in a processed format obtained by using an embedded adaptive histogram equalisation method.

BI-RADS density classifications

Breast density evaluation was performed by another two blinded radiologists (M.C. and A.T.) with 20 and 5 years of experience in breast examination and with more than 6000 examinations reported every year on the FFDM images. Inter-observer agreement between the two radiologists was calculated. The evaluation was made using the quantitative BI-RADS, which has four density categories according to the parenchymal structure (D1: 0-25%; D2: 26-50%; D3: 51-75%; D4 >76%) because this method seems more accurate in the evaluation of breast density.

Tomosynthesis

Digital breast tomosynthesis was performed by three dedicated technologists trained using a commercially available device (Hologic Selenia™Dimensions™ System). The device used consists of a custom-designed high-power (mA) tungsten (W) anode X-ray tube, and X-ray filters of rhodium (Rh), silver (Ag) and aluminium (Al). These
different filters are used in 2D and 3D imaging and produce optimal X-ray spectra based on breast thickness/composition and imaging modes. With this achievement, patient radiation exposure is minimised maintaining high image quality and low exposure. The image receptor is a 70-µm pixel pitch selenium direct-capture detector. The X-ray tube moves over a 15° arc while the breast is compressed, taking a series of ultra low-dose mammograms. The projections are then combined to create a full 3D image set of the breast, with 1-mm slices through the breast. Each DBT data set consisted of 15 projection images.

Dataset and Mammogram density analysis with fully automated software

The data set comprised the digital mammograms and the DBT projections obtained in 50 patients (mean age, 51 years; range, 35-83 years). All DBT projections were analysed and the mean value obtained was used for comparison with digital mammography. This is different from previously published papers in which only the central tomosynthesis projection had been evaluated [10].

For analysis we used software previously employed on full digital and analogical mammograms [11, 14]. We performed the evaluation using both methods available: the first method is based on the integral curve F(i) of the histogram and the second method is based on the maximum entropy thresholding method developed by Shannon (described in Tagliafico et al. [11]).

Radiation dose

To compare clinical dose differences of DBT with those of (FFDM) in a diagnostic population, mammographic examination acquisition data were collected in order to determine in both cases entrance surface air kerma (ESAK) and mean glandular dose (MGD), according to the European Reference Organisation for Quality Assured Breast Screening and Diagnostic Services (EUREF) Guidelines 2006 [15]. In tomosynthesis, additional integration and consideration are necessary regarding beam quality and therefore regarding parameters to calculate MGD and arc-technique acquisition: a simple formalism for the estimation of MGD in tomosynthesis has been successfully employed [16]. The method has been applied in our Institute to compare FFDM and DBT according MGD performance using both in vivo dosimetry with metal oxide semiconductor field effect transistor (MOSFET) [17] and data collection analysis [15]. MOSFET has been considered acceptable because its sensitivity is stable and the response is almost linear in spite of the 15° rotation of the X-ray tube. With DBT as a replacement for FFDM, the increase is 18% in average ESAK and 30% in MGD, with 3 mGy as average MGD for a single view. DBT increases ESAK and MGD, but values are within the limits of the EUREF Guidelines 2006 [15, 17].
Statistical analysis was performed using the two-paired Student's t-test to compare breast density obtained on mammograms and DBT and Bland-Altman statistics. Values were expressed as mean ± standard deviation. To correlate breast density obtained on digital mammograms and DBT, Pearson’s test and linear regression analysis were used. Probability (P) values <0.05 were considered statistically significant. All analyses were performed with software (SPSS for Windows, release 10.1.3; SPSS, Chicago, IL, USA and MedCalc for Windows).
Results

Programme performance and time

None of the FFDM or DBT images was excluded from the evaluation owing to technical problems. A very brief training period is needed to get used to the software interface and to all the features of the tool. The learning curve of this programme was very short and all the radiologists involved in this study were able to make their evaluations in less than 10 min (mean: 8 min). The mean time needed to complete the fully automated analysis was 6 min per DBT data set (range: 2-8 min).

FFDM vs. DBT using the integral curve

Using the first method based on the integral curve $F(i)$ of the histogram, FFDM overestimated breast density in 16.2%. The 95% limits of agreement between the two methods were 2.12 and 25.90. The mean values and standard deviation of percentage breast density are $68.1 \pm 12.1$ for FFDM and $51.9 \pm 6.5$ for DBT. The differences in breast percentage density between DBT and FFDM had a highly significant result ($P<0.0001$).

In DBT, statistical significant differences between central and lateral projections have been recorded ($P<0.05$). Lower values have been measured in the central projections.

FFDM vs. DBT using the maximum entropy method

Using the maximum entropy thresholding method developed by Shannon, FFDM overestimated breast density in 11.4%. The 95% limits of agreement between the two methods were 3.14 and 29.81. The mean values and standard deviation of breast percentage density are $52.8 \pm 9.6$ for FFDM and $41.4 \pm 12.4$ for DBT. The differences in breast percentage density between DBT and FFDM had a highly significant result ($P<0.0001$). Descriptive statistics are reported in Table 1 and Fig. 1.

In DBT, statistically significant differences between central and lateral projections have been recorded ($P<0.005$) as well.

We considered the second method more reliable; therefore, for subsequent analysis, values of FFDM and DBT obtained with the maximum entropy method were considered.

There was a good correlation between BI-RADS categories on a four-grade scale and the density evaluated with DBT and FFDM ($r=0.54$, $P<0.01$ and $r=0.44$ $P<0.01$). A very
good correlation ($r=0.78$, $P<0.01$ and $r=0.81$ $P<0.01$) was present with a two-grade scale (D1-2/D3-4). Overall agreement between DBT, FFDM and radiologists' BI-RADS was good ($k=0.80$ and $k=0.82$). The agreement was better for D1 and D4 categories ($r=0.88$ and $r=0.92$ respectively). Lower levels of agreement were seen on D2 and D3 categories ($r=0.70$ and $r=0.61$, respectively).

Using the BI-RADS method, intra-observer and inter-observer agreement of the two radiologists in the evaluation of breast density were considered to be very good (reader 1: $k=0.81$; reader 2: $k=0.86$; reader 1 vs. reader 2: $k=0.91$).

**Radiation dose**

The mean glandular dose was $2.7 \pm 0.7$ mGy for the FFDM system and $2.4 \pm 0.6$ mGy for DBT.
Fig. 1: Comparison of breast density values estimated with the maximum entropy method (FFDM: full-field digital mammography; DBT: digital breast tomosynthesis).

© The full paper will be published soon by Eur Rad

<table>
<thead>
<tr>
<th>Method</th>
<th>Mean Value ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>FFDM</td>
<td>68.1 ± 12.1</td>
</tr>
<tr>
<td>DBT</td>
<td>51.9 ± 6.5</td>
</tr>
<tr>
<td>Maximum Entropy</td>
<td></td>
</tr>
<tr>
<td>FFDM</td>
<td>52.8 ± 9.6</td>
</tr>
<tr>
<td>DBT</td>
<td>41.4 ± 10.4</td>
</tr>
<tr>
<td>BI-RADS</td>
<td></td>
</tr>
<tr>
<td>Reader 1</td>
<td>2.4 ± 0.9</td>
</tr>
<tr>
<td>Reader 2</td>
<td>2.5 ± 0.8</td>
</tr>
</tbody>
</table>

FFDM: full-field digital mammography; DBT: digital breast tomosynthesis
Fig. 2: Descriptive statistics (mean value and standard deviation) for breast density estimated with the three different methods

© The full paper will be published soon by Eur Rad
Conclusion

Our study represents a comparison of breast density estimated on FFDM and on all DBT projection images in the same patient.

Breast density values were significantly underestimated on DBT projections.

These data have to be taken into account in clinical and research studies that include breast density assessment.

Key Points:

- *Breast density is considered to be an independent risk factor for cancer*

- *Density can be assessed on full-field digital mammography and digital breast tomosynthesis*

- *Objective automated estimation of breast density eliminates subjectivity*

- *Automated estimation is more accurate than BI-RADS quantitative evaluation*

- *Breast density seems to be significantly underestimated on digital breast tomosynthesis*
References


Personal Information

The full paper of the article will be published soon on Eur Radiol.