Does wavelet compression technique affect a diagnostic performance of digital mammograms?

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Purpose

To evaluate the influence of the wavelet compression technique on diagnostic accuracy for detection of masses and clustered microcalcifications (MCLs) on digital mammograms [1] [2].
Methods and Materials

The images used in this study were acquired with institutional review board approval. Patient identification was removed from the images.

Case selection:

1. The control subjects were selected from the participants in a breast cancer screening program conducted in 2006. Only the mediolateral oblique (MLO) view was obtained in the screening program at the time of this study. A radiologist randomly selected 173 cases, and then selected 52 subjects to balance the distribution of the background breast density (breast composition), according to the classification of breast composition in the Breast Imaging Reporting and Data System (BI-RADS).

2. A total of 141 positive cases were chosen among the patients who underwent preoperative mammography from 2006 to 2008, all of which were surgically confirmed. The same reviewers retrospectively examined their preoperative mammograms and selected 45 patients as the positive subjects in our study. The population consisted of 27 patients with clustered MCLs, 32 patients with masses or other findings (i.e., those with two or more findings).

We used only the MLO view of the mammograms to match the screening mammograms. In total, we prepared material for 194 digital mammograms of 97 subjects. For this group, the breast composition is shown in Table 1.

<table>
<thead>
<tr>
<th>Breast composition</th>
<th>Control</th>
<th>Breast cancer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely dense</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Heterogenous dense</td>
<td>17</td>
<td>13</td>
</tr>
<tr>
<td>Scattered fibroglandular</td>
<td>26</td>
<td>25</td>
</tr>
<tr>
<td>Entirely fatty</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td>45</td>
</tr>
</tbody>
</table>

Table 1: Distribution of breast composition of control and breast cancer subjects

References: - Sendai/JP
**Digital technology**

All images were obtained using the Computed Radiography (CR) with a Regius PureView Phase Contrast Mammography System (Konica Minolta, Hino, Japan). The pixel size was 25 µm and the matrix size was 7,080×9,480.

**Image compression:**

Each image was compressed with JPEG 2000 image compression software using the wavelet compression technique. The software allowed creation of the compression image from which a compression ratio differs by arbitrarily setting up the value of the Quality Factor (QF). Two data compression conditions-ratios of 1:1 (no compression) and 130:1-were investigated using the lossy compression method, which allowed image compression at higher ratios. Figure 1 (Fig. 1 on page 6) shows the effect of different compression ratios on the appearance of clustered MCLs.

**Soft-copy reading system:**

- The images were displayed on a 5-MP LCD monochrome monitor (MDM2010-5NC; CHILIN, Tainan, Taiwan). The greyscale tones were adjusted to Digital Imaging and Communications in Medicine (DICOM) Part 14 greyscale standard display function (GSDF).
- The viewer system used Sumire software only for mammography (Rise Corp., Miyagi, Japan).

**Image assessment:**

- Five observers were recruited for the study, excluding the reviewers who selected the subjects. The observers included two radiologists and three breast surgeons, each with approximately 4-8 years of experience in mammography. They participated in two reading sessions for the observer study of detection of masses or other findings and MCLs: one with a compression ratio of 1:1 and one with a compression ratio of 130:1.
- In the two reading sessions, the order of the 97 subjects was changed. No time limit existed for the two sessions, and the interval between the two sessions was at least 3 weeks. The images were displayed to fit the area of the LCD monitor. All observers were allowed to freely adjust the width and level of the window and to magnify the images. In every session, the ambient lighting was set at approximately 20 lux, which was determined before every reading session using a lux meter (T-10; Konica Minolta, Hino, Japan).
**Image interpretation:**

The readers recorded the finding and its location on both sides. They were then asked to record the probability of malignancy [3].

We used the following seven-point malignancy scale:

1. definitely not malignant
2. almost certainly not malignant
3. probably not malignant
4. possibly malignant
5. probably malignant
6. almost certainly malignant
7. definitely malignant.

We also used a continuous point scale (0-100), in which a score of 0 implies that the observer is convinced that no breast lesion exists and a score of 100 implies that the observer is convinced that a breast lesion is present.

**Statistical analysis:**

- A receiver operating characteristic (ROC) analysis was performed [4]. The software computed the area under the mean ROC curve (AUC) according to lesion type (a mass or other finding, and clustered MCLs) generated by the five observers using the jackknife method (LABMRMC v1.4b; Metz CE, University of Chicago, Chicago, IL, USA).
- The ROC curves were generated using plotROC (Metz CE). The differences in AUC value based on the 95% confidence interval were evaluated.
Table 1: Distribution of breast composition of control and breast cancer subjects

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<td>Total</td>
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Fig. 1: Magnified region of interest containing a cluster of microcalcifications on an MLO view mammogram. (a) Original uncompressed region of about 124 MB. (b-d)
Same region in (a) with compressed images: (b) approximately 4.2 MB, yielding a compression rate of 30:1; (c) approximately 2.3 MB, yielding a compression rate of 54:1; (d) approximately 1.6 MB, yielding a compression rate of 80:1; and (e) approximately 957 kB, yielding a compression rate of 130:1.

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Results

**Detection of a mass or other finding:**

The average AUC values for all observers for each compression ratio are shown in Table 2. The average ROC curves for the five observers for each compression ratio are shown in Figures 2 and 3 (Fig. 2 on page 10 and Fig. 3 on page 11).

1. **Seven-point scale**

The AUC values were 0.8702±0.0328 [(mean±standard error (SE)] for the original uncompressed images and 0.8745±0.0633 for compressed images (Table 2 on page 10). The 95% confidence interval was -0.0919 to 0.0833 (p=0.9228).

2. **Continuous scale**

The average AUC values were 0.8435±0.0320 and 0.8781±0.0544 for uncompressed and compressed images, respectively (Table 2 on page 10). The 95% confidence interval was -0.1373 to 0.0680. The AUC for each observer is shown in Table 3 on page 10. Although the average AUC values for detection of masses were slightly increased in the compressed images (AUC=0.8435) compared with the uncompressed images (AUC=0.949) and only one observer showed slightly decreased performance, the difference between the average AUC values was not statistically significant (p=0.4267).

**Detection of clustered MCLs:**

The average AUC values for all observers for each compression ratio are shown in Table 4. The average ROC curves for the five observers for each compression ratio are shown in Figures 4 and 5 (Fig. 4 on page 13 and Fig. 5 on page 14).

1. **Seven-point scale**

The AUC values were 0.9396±0.0233 (mean±SE) for the original uncompressed images and 0.9563±0.0322 for compressed images (Table 4 on page 12). The 95% confidence interval was -0.0728 to 0.0395 (p=0.481).

2. **Continuous scale**
The average AUC values were 0.9273±0.0236 and 0.9497±0.0301 for uncompressed and compressed images, respectively (Table 4 on page 12). The 95% confidence interval was -0.0757 to 0.0310. The AUC for each observer is shown in Table 5 on page 13. Although the average AUC values for the detection of clustered MCLs were slightly increased in the compressed images (AUC= 0.9273) compared with the uncompressed images (AUC=0.9497), and only one observer showed slightly decreased performance, the difference between the average AUC values was not statistically significant (p=0.3554).
Images for this section:

<table>
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<tr>
<th></th>
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<th>ΔAUC</th>
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<td>Compressed</td>
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<tr>
<td>Continuous</td>
<td>0.8435</td>
<td>0.8781</td>
<td>-0.0347</td>
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**Table 2**: The area under the mean ROC curve of the original uncompressed images and compressed images for masses

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<table>
<thead>
<tr>
<th>Observer</th>
<th>AUC</th>
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<th>95% Confidence Interval</th>
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<tr>
<td></td>
<td>Uncompressed</td>
<td>Compressed</td>
<td>(LB, UB)</td>
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<tr>
<td>Reader1</td>
<td>0.7914</td>
<td>0.7102</td>
<td>-0.0598, 0.2223</td>
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<tr>
<td>Reader2</td>
<td>0.8158</td>
<td>0.858</td>
<td>-0.1386, 0.0542</td>
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<tr>
<td>Reader3</td>
<td>0.9366</td>
<td>0.9868</td>
<td>-0.1507, 0.0503</td>
</tr>
<tr>
<td>Reader4</td>
<td>0.813</td>
<td>0.9679</td>
<td>-0.2134, -0.0965</td>
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<tr>
<td>Reader5</td>
<td>0.8606</td>
<td>0.8678</td>
<td>-0.2193, 0.2048</td>
</tr>
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</table>

**Table 3**: The area under the ROC curve of the original uncompressed images and compressed images in a continuous malignancy scale for the detection of masses

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Fig. 2: The average ROC curves for the performances of the five observers in the detection of masses using the seven-point scale for the probability of malignancy. The thick line indicates the ROC curve for the original uncompressed images and the dashed line represents the ROC curve for the compressed images. No significant difference was detected.

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**Fig. 3:** The average ROC curves for the performances of the five observers in the detection of masses using the continuous scale probability of malignancy. The thick line indicates the ROC curve for the original uncompressed images and the dashed line represents the ROC curve for the compressed images. No significant difference was detected.

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<table>
<thead>
<tr>
<th></th>
<th>Umcompressed</th>
<th>Compressed</th>
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<tr>
<td>7-point scale</td>
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<td>0.9273</td>
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</table>

**Table 4:** The area under the mean ROC curve of the original uncompressed images and compressed images for the detection of clustered microcalcifications
Table 5: The area under the ROC curve of the original uncompressed images and compressed images in a continuous malignancy scale for the detection of clustered microcalcifications.

<table>
<thead>
<tr>
<th>Observer</th>
<th>AUC Uncompressed</th>
<th>AUC Compressed</th>
<th>95% Confidence Interval (LB, UB)</th>
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</thead>
<tbody>
<tr>
<td>Reader1</td>
<td>0.8951</td>
<td>0.8528</td>
<td>-0.256 0.1101</td>
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<tr>
<td>Reader2</td>
<td>0.9107</td>
<td>0.9817</td>
<td>-0.1261 -0.0159</td>
</tr>
<tr>
<td>Reader3</td>
<td>0.9487</td>
<td>0.9923</td>
<td>-0.1081 0.021</td>
</tr>
<tr>
<td>Reader4</td>
<td>0.9055</td>
<td>0.945</td>
<td>-0.1477 0.0687</td>
</tr>
<tr>
<td>Reader5</td>
<td>0.9764</td>
<td>0.9764</td>
<td>-0.0246 0.0245</td>
</tr>
</tbody>
</table>
**Fig. 4:** The average ROC curves for the performances of the five observers in the detection of clustered microcalcifications using the seven-point scale for the probability of malignancy. The thick line indicates the ROC curve for the original uncompressed images and the dashed line represents the ROC curve for the compressed images. No significant difference was detected.

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![ROC curve graph](image)

**Fig. 5:** The average ROC curves for the performances of the five observers in the detection of clustered microcalcifications using the continuous scale probability of malignancy. The thick line indicates the ROC curve for the original uncompressed images and the dashed line represents the ROC curve for the compressed images. No significant difference was detected.

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Conclusion

Given the accuracy of these measurements, the diagnostic performance for detection of masses and clustered MCLs on CR digital mammograms was not affected by using the wavelet compression method.
References


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