Computer-Aided Detection of Breast Cancer Using an Ultra High-Resolution Liquid Crystal Display: Reading Session Analysis

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Abstract. We performed a reading session to examine the validity of computer-aided detection for mammograms using a 3-megapixel liquid crystal display (LCD). Digital mammograms of 225 patients (ROLAD M-IV and FCR9000, 100 μ/pixel), were divided into 3 data sets (each set consisting of 75 patients, including 30 with pathologically proven breast cancer) for this reading session. Fifteen physicians interpreted these three data set using 3 different imaging modalities; hard copy, LCD without computer-aided detection (CAD), and LCD with CAD. Then they categorized the images into 4 ranks according to the confidential levels of cancer. Sensitivity and specificity were calculated individually for each of the 3 different modalities, and then ROC analysis was performed. The sensitivity, specificity, and Az values showed no significant differences between LCD with out CAD and hard copy. Also, no significant differences were found between LCD with CAD and the other modalities for these 3 values. The results of this study indicate that it is reasonable to use a 3-megapixel LCD for interpretation of digital mammograms instead of conventional hard copy. Nevertheless, because the usefulness of the CAD system has not been fully ascertained, further studies are required.

1 Background

The morbidity and mortality rate of breast cancer in Japan are showing a tendency to increase. Since early detection of breast cancer is essential to decrease deaths from this disease, the importance of screening for breast cancer by mammography (MMG) is currently emphasized. Therefore, MMG will be introduced for breast cancer screening and the frequency of reading mammograms will increase rapidly as a result. However, it is feared that the number of interpreters specializing in diagnosis of mammograms will not be adequate to cope with such a rapid increase in demand. On the other hand, it has been reported that the false-negative rate of MMG for breast cancer screening is above the acceptable range. Since the quality of image interpretation largely depends on the training, experience, and diligence of the interpreter performing the task, it is important to develop an image reading system that can cope with such a rapid increase in the frequency of reading mammograms, while ensuring the high quality of interpretation.

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Computer-aided detection (CAD) is one of the methods that can be used to solve this problem. Computer technology has made rapid advances in recent years, and CAD has been reported to be useful for cancer screening by chest CT. Application of CAD to MMG has been performed clinically since the U.S. Food and Drug Administration approved the first commercial CAD system in 1998. Digitization of information is essential for the use of CAD, and 2 methods are available for this purpose, which are 1) the digitization of conventional radiographic films and 2) direct use of digital data obtained by digital radiography, including computed radiography (CR). The diagnostic accuracy of MMG performed with CR (CR-MMG) is adequate in the case of hard copy. However, to use a system employing CAD more efficiently, it is obvious that a liquid crystal display (LCD) should be employed instead of the hard copy. However, it is necessary that the accuracy of image interpretation using LCD should be equal to that of using hard copy. In the present study, we performed a large-scale reading session to compare the diagnostic accuracy between LCD and hard copy in order to investigate the usefulness of a CR-MMG CAD system.

2 Materials and Methods

At the National Cancer Center Hospital East, CR-MMG was performed in 1,300 patients over 1 year from 1998 to 1999 using LORAD M-IV () and FCR9000 (Fuji Photo Film, Tokyo, Japan). The sampling size was 0.1 mm. From these 1,300 patients, 90 patients with pathologically confirmed breast cancers (≤20 mm) and 135 patients without breast cancer based on pathological examination or follow-up were selected. These 90 breast cancer patients and 135 patients without breast cancer (225 patients in total) were divided into 3 data sets, each of which comprised 75 patients including 30 with breast cancer. During the process of obtaining patients for the data sets, patients for whom it was excessively difficult to make a diagnosis and patients whose images were not obtained in adequate body positions were excluded by consensus between 3 radiologists who were experienced in reading mammograms, so that the difficulty of diagnosis was equalized among the data sets. Patients with bilateral breast cancer and a history of prior treatment for breast cancer were also excluded.

The LCD used for this reading session was an SL-IC300G (Fuji Photo Film, Tokyo, Japan). This was a so-called 3-megapixel LCD with a matrix of 2,048 × 1,536 pixels. The pixel size was 0.207 mm, the brightness was 500 cd/m^2, the contrast ratio was 600:1, and the gray scale resolution was 766. When reading the images, increasing the magnification and changing the window level/window width were possible. As the hard copy for this reading session, laser prints from a DryPix7000 (Fuji Photo Film, Tokyo, Japan) and DI-AL films (Fuji Photo Film, Tokyo, Japan) were used. We employed 12 bit D/A conversion, 0.05 mm writing, and 3.6 Dmax. For the characteristic curve of CR, pure T-gradation and pattern enhancement processing for mammography (PEM) were combined.

The CAD software used for this reading session was developed jointly by Tokyo University of Agriculture and Technology, Fuji Photo Film Co., Ltd., and us. Image data were transmitted directly from the FCR9000 to a computer for CAD. Candidate regions of tumor masses and microcalcifications were calculated separately using different programs. These regions were indicated with arrows and rectangles for