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Teleradiology with uncompressed digital mammograms: Clinical assessment

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ABSTRACT

Purpose: The purpose of our study was to demonstrate the feasibility of sending uncompressed digital mammograms in a teleradiologic setting without loss of information by comparing image quality, lesion detection, and BI-RADS assessment.
Materials and methods: CDMAM phantoms were sent bidirectionally to two hospitals via the network. For the clinical aspect of the study, 200 patients were selected based on the BI-RAD system: 50% BI-RADS I and II; and 50% BI-RADS IV and V. Two hundred digital mammograms (800 views) were sent to two different institutions via a teleradiology network. Three readers evaluated those 200 mammography studies at institution 1 where the images originated, and in the two other institutions (institutions 2 and 3) where the images were sent. The readers assessed image quality, lesion detection, and BI-RADS classification.
Results: Automatic readout showed that CDMAM image quality was identical before and after transmission. The image quality of the 200 studies (total 600 mammograms) was rated as very good or good in 90–97% before and after transmission. Depending on the institution and the reader, only 2.5–9.5% of all studies were rated as poor. The congruence of the readers with respect to the final BI-RADS assessment ranged from 90% and 91% at institution 1 vs. institution 2, and from 86% to 92% at institution 1 vs. institution 3. The agreement was even higher for conformity of content (BI-RADS I or II and BI-RADS IV or V). Reader agreement in the three different institutions with regard to the detection of masses and calcifications, as well as BI-RADS classification, was very good (κ: 0.775–0.884). Results for interreader agreement were similar.
Conclusion: Uncompressed digital mammograms can be transmitted to different institutions with different workstations, without loss of information. The transmission process does not significantly influence image quality, lesion detection, or BI-RADS rating.

1. Introduction

About one million women are newly diagnosed with breast cancer annually. The best way to lower the mortality rate is to diagnose breast cancer at an early stage, as the treatment of small tumours differs, particularly for those tumours that can be removed without the need for mastectomy, obviating the need for chemotherapy and irradiation in many cases [1,2]. Mammography is the first-line tool by which to diagnose breast cancer at an early stage. Several randomized trials have shown that this method reduces mortality significantly [3–6]. Digital mammography has been increasingly used for diagnostic and screening mammography [7–9]. One of the advantages of digital mammography is that the original data can be sent digitally to other read-out centres. With teleradiology, digital images can be transferred from one location to another via data link [10–12]. Other applications for teleradiology include after-hours coverage [13], service in remote areas [14], and subspecialty or expert reading, as this would apply for digital mammography. Indeed, reports have even been published describing radiological images that were transmitted to hand-held devices and to smart phones [15–17]. When teleradiology was initially attempted with mammograms, difficulties arose because of technical limitations, mainly due to limited transmission capacities and problems with displaying the images [18,19]. Some centres overcome these problems by compressing images for transmission [20]. Currently, digital mammography systems and PACS archives with large storage capacity, and data links with extremely high transmission rates, are at our disposal. These advantages make teleradiology with mammograms

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possible and enable an easy-to-handle workflow. To our knowledge, only few studies exist about teleradiology for mammography screening programs' [21] and secondarily digitized and compressed mammograms [20]. To date, no clinical trial has been published where uncompressed digital mammograms were sent via data link.

Thus, the purpose of our study was to demonstrate the feasibility of sending uncompressed digital mammograms in a teleradiologic setting without loss of information by comparing image quality, lesion detection, and BI-RADS assessment.

2. Materials and methods

The ethics committee of our medical university approved this study. Three different institutions were involved.

2.1. Teleradiology setting

The hospital information technology department provides the teleradiology network. The system is based on a Centricity RA600 V7.0 (GE Healthcare, Milwaukee, WI, USA) console. A broadband, 1 gigabit, non-encrypted port-to-port connection is used for the transfer of DICOM images.

2.2. Phantom study

The CDMAM (Contrast Detail Mammography) phantom type 3.4 (Artinis Nijmegen; Netherlands) consists of a 0.05 mm thick aluminium base with gold discs of various thicknesses (0.03 μm up to 2 μm) and diameters (0.06 mm up to 2 mm), which is attached to a Plexiglas cover. The discs are arranged in 16 rows and 16 columns (see CDMAM Fig. 1). Under standard mammography-exposure conditions (Mo-anode, 30 μm Mo-filtration, 28 kVp), the phantom has a PMMA-equivalent thickness of 10 mm.

CDMAM images ($n = 17$) were obtained on a GE Senographe 2000D System (GE Medical Systems, Milwaukee, WI, USA). These DICOM images (each 8.4 MB, total 142.8 MB) were sent in a 14-s transfer time without compression or modification, bidirectionally, via the network. Using CDMAM phantoms, we assessed the transmission quality between the different institutions (institutions 1 and 2). After that, the original (institution 1) and the sent CDMAM images (institution 2) in raw format were analysed with "automatic readout" by the CDMAM analysing software (NHS-UK), [22] and the resultant CDMAM image quality was compared to the original images.

2.3. Clinical trial

2.3.1. Image selection

In the fist phase of the clinical study, 200 cases were retrospectively selected. Mammograms were obtained in two views (craniocaudal and mediolateral oblique) with a full-field digital flat-panel system (Senographe 2000D, GE Medical Systems, Milwaukee, WI, USA). The examinations were retrospectively selected by full-text research in our radiology information system (RIS) according to the BI-RAD system (Breast Imaging Reporting and Data System [23]). We used the following search algorithm: of the 200 studies 50 studies had to be BI-RADS I reports, 50 BI-RADS II, 50 BIRADS IV, and 50 BIRADS V. Of the 100 BI-RADS IV and V reports, 50% had to have a finding classified as a mass and 50% a finding classified as a calcification.

2.3.2. Equipment

At institution 1, the 200 studies were retrieved from the PACS (AGFA-Healthcare, Mortsel Belgium, select version 52.5) at the reading workstation (Seno Advantage 2.1, GE Medical Systems, Milwaukee, WI, USA). At institution 1, the 200 digital mammograms were anonymized and sent in DICOM format via the transmitting unit (Centricity RA 600 v. 7.0.A) to the two other institutions. At Institution 2, the 200 studies were received on a Siemens system and were automatically transferred to the reading workstation (Syngo MammoReport; Siemens Medical Solutions, Forchheim, Germany). At institution 3, the 200 studies were received on a GE system, and again, were sent automatically to the reading workstation (Seno Advantage, GE Medical Systems, Milwaukee, WI, USA). All workstations were equipped with 21,2″5k LCD monitors.

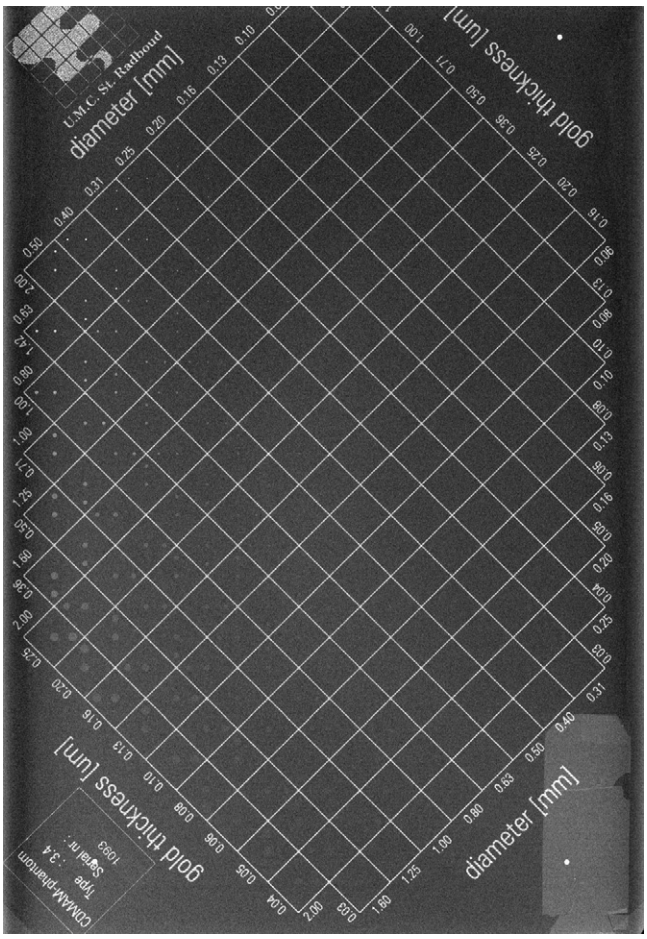

Fig. 1. CDMAM phantom.

2.3.3. Analysis

Three experienced breast imagers evaluated the 200 digital mammography studies (in total, 600 mammograms, 2400 mammography views) independently at three different institutions. No prior examinations were provided. The readers were also blinded to patient name, age, and clinical history. The three institutions were equipped with different vendors' workstations, but all workstations had two viewing monitors. All four images appeared on the two monitors at the same time; on the left monitor the craniocaudal views, and on the right monitor the medial oblique views. The images were displayed with the institution's individual settings and no adjustment was allowed. The use of the magnification tools was allowed, if necessary. No CAD (computer-aided diagnosis) system was available. The radiologists first assessed the image quality of each study (including all four mammography views) with regard to brightness, contrast, sharpness, noise, skin, fat, and retromammillary space [24], with a score from 1 to 5 (1 = very good;