Multiplanar Reconstructions of 3D Automated Breast Ultrasound Improve Lesion Differentiation by Radiologists

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Abbreviations

ABUS automated breast ultrasound; **ACR** American College of Radiologists; **AUC** area under the (ROC) curve; **BI-RADS** breast imaging reporting and data system; **HHUS** handheld ultrasound; **ICC** intraclass correlation coefficient; **LOM** likelihood of malignancy; **MPR** multiplanar reconstructions; **MR/MRI** magnetic resonance imaging; **MRMC** multiple case multiple readers; **ROC** receiver-operating characteristics; **SRSI** Spiculation and Retraction Severity Index; **US** ultrasound

Rationale and Objectives: To investigate the value of multiplanar reconstructions (MPRs) of automated three-dimensional (3D) breast ultrasound (ABUS) compared to transverse evaluation only, in differentiation of benign and malignant breast lesions.

Materials and Methods: Five breast radiologists evaluated ABUS scans of 96 female patients with biopsy-proven abnormalities (36 malignant and 60 benign). They classified the most suspicious lesion based on the breast imaging reporting and data system (BI-RADS) lexicon using the transverse scans only. A likelihood-of-malignancy (LOM) score (0–100) and a BI-RADS final assessment were assigned. Thereafter, the MPR was provided and readers scored the cases again. In addition, they rated the presence of spiculation and retraction in the coronal plane on a five-point scale called Spiculation and Retraction Severity Index (SRSI). Reader performance was analyzed with receiver-operating characteristics analysis.

Results: The area under the curve increased from 0.82 to 0.87 (P = .01) after readers were shown the reconstructed planes. The SRSI scores are highly correlated (Spearman's r) with the final LOM scores (range, r = 0.808–0.872) and ΔLOM scores (range, r = 0.525–0.836). Readers downgraded 3%–18% of the biopsied benign lesions to BI-RADS 2 after MPR evaluation. Inter-reader agreement for SRSI was substantial (intraclass correlation coefficient, 0.617). Inter-reader agreement of the BI-RADS final assessment improved from 0.367 to 0.536 after MPRs were read.

Conclusions: Full 3D evaluation of ABUS using MPR improves differentiation of breast lesions in comparison to evaluating only transverse planes. Results suggest that the added value of MPR might be related to visualization of spiculation and retraction patterns in the coronal reconstructions.

Key Words: Breast; neoplasm; ultrasound; diagnosis.

Handheld ultrasound (HHUS) is a standard diagnostic modality in breast cancer diagnosis. HHUS is also increasingly used for screening because of the increasing awareness of underperformance of mammography in women with dense breasts. Additional screening with bilateral whole breast HHUS in these women improves the cancer detection rate (1–4). However, HHUS whole breast screening is time consuming and should be performed by a trained physician. HHUS is therefore relatively expensive. Automated three-dimensional (3D) breast ultrasound (ABUS) can overcome these limitations of HHUS. The acquisition is performed by a technician who positions the automatically driven wide linear array transducer for each volume on a predefined location of the breast. Depending on the size of the breast, three–five separate ABUS volumes are required for full breast coverage (5,6). The acquisition of standardized volumes enables comparison of new examinations to relevant priors, which is not feasible with HHUS.

ABUS volume scans consist of a series of sequential transverse images. These are reconstructed into coronal and sagittal images on a dedicated workstation (Fig 1). Coronal reconstructions provide a comprehensive view of the breast anatomy (5) and visualize the effect of breast lesions on

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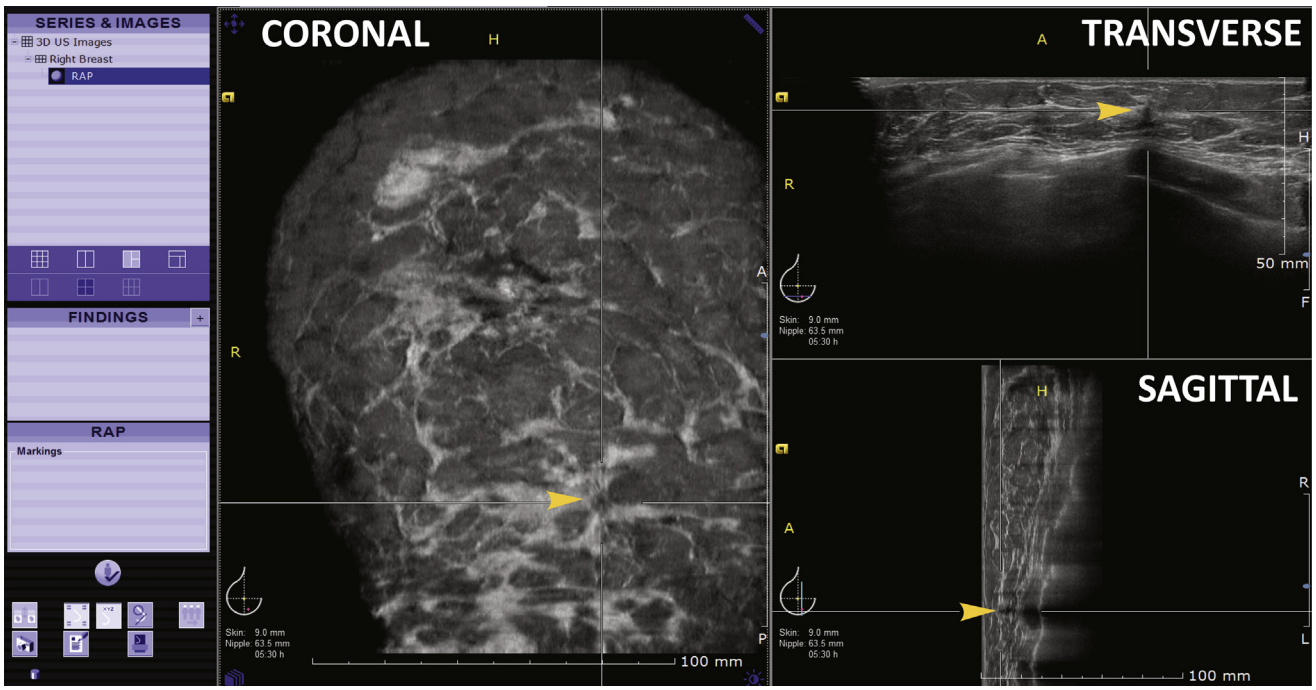

Figure 1. Multiplanar reconstructions of automated breast ultrasound (ABUS) and reading protocol. The original transverse ABUS images are reconstructed into coronal and sagittal planes. The reader can therefore view the breast lesion in three orthogonal planes (eg transverse, coronal, and sagittal). The coronal reconstructions provide a comprehensive view on the breast anatomy. During the reader experiment, the readers initially were shown the transverse images only on full screen (top plane of this figure only) to classify the most suspicious lesion. Thereafter, the MPRs were shown and readers were asked to classify the lesion again and rate spiculation and retraction in the coronal plane. (Color version of figure is available online.)

neighboring breast tissue (7,8). Spiculation of malignant lesions and the retraction phenomenon caused by an accompanying desmoplastic reaction give rise to architectural distortion, which is best viewed in this coronal plane (9–11). The architectural distortion discriminates strongly between benign and malignant breast lesions (12,13).

Recent studies investigated reader variability in ABUS using the breast imaging reporting and data system (BI-RADS) lexicon and scoring system for breast US showing good reproducibility of ABUS interpretation (8,14). Moreover, agreement between observers seems to be similar or even higher when compared to HHUS inter-reader agreement (15–18). Standard HHUS systems do not enable the user to evaluate lesions in the coronal plane and the BI-RADS lexicon provides no particular descriptors for lesions in coronally reconstructed ABUS images. Additional descriptors would help to standardize and eventually improve breast lesion characterization in ABUS images. Standardization is desired because screening with ultrasound detects many otherwise unobserved benign lesions, some of which may require histologic verification (1,19,20). Consequently, improvement of ABUS-based lesion characterization may help to reduce referrals and avoid unnecessary biopsies.

The purpose of this study was to investigate the incremental value of multiplanar reconstructions (MPRs) of ABUS in differentiation between benign and malignant breast lesions. In addition, we evaluated the importance of the better visibility of spiculation and retraction in the coronal plane.

METHODS

We performed a retrospective multireader multicase study (MRMC) in a sequential design (21,22) using ABUS scans of women who underwent histologic biopsy for a breast lesion. The institutional review board approved the study, allowed the use of medical images, and waived the need for informed consent.

Inclusion and Exclusion of Patients

We searched our consecutive database of female patients who underwent ABUS scans between October 2010 and October 2012. Scans were included when they contained a lesion that was confirmed by an HHUS examination and biopsied under ultrasound guidance. This yielded a total of 136 patients.

Exclusion criteria were inconclusive US biopsy results followed by magnetic resonance (MR) biopsy (n = 16) or stereotactic biopsy (n = 1). These patients had lesions that were detected on MRI or mammography and were not unambiguously reproducible by HHUS and consequently MR biopsy or stereotactic biopsy followed. Furthermore, we excluded nonbreast lesions (n = 1), ultrasound-guided drainage of uncomplicated cysts (n = 5), poor quality scanning where