A Comparison Study between Compound Imaging and Conventional Ultrasonography in Subareolar Area

[1]Department of Diagnostic Radiology, Konkuk University Hospital, [2]Department of Diagnostic Radiology, Korea University Hospital, [3]Department of Preventive Medicine, Korea University, [4]Department of General Surgery, Korea University Hospital, [5]Department of Internal Medicine, Korea University Hospital

Bo Kyoung Seo, M.D.[1], Hae Jeong Jeon, M.D.[1], Jeong Hee Park, M.D.[1]
Kyu Ran Cho, M.D.[2], Ji Young Lee, M.D.[2], Bo Kyung Je, M.D.[2]
Eun Jeong Choi, M.D.[2] June Young Lee, Ph.D.[3]
Jeoung Won Bae, M.D.[4] and Seok Jin Kim, M.D.[5]

Purpose: The subareolar area is often difficult to evaluate ultrasonographically due to tissue shadowing, which obscures visualization of ducts and parenchymal tissue. The purpose of this study is to determine if real-time compound imaging improves evaluation of normal subareolar tissue and solid nodules in subareolar area compared to conventional ultrasonography.

Methods: 190 images of the subareolar area were obtained from 135 patients from March 2001 to July 2002. Thirty-three of 190 images showed solid nodules, extraductal nodules in 30 and intraductal nodules in three. We scanned both conventional and compound imaging with a stationary probe, to maintain an identical projection and tissue pressure. We used two compound techniques; survey mode (S) is made by 3 coplanar images and target mode (T) by 9 coplanar images. The evaluating points were 1) reduction in the density of shadowing, 2) resolution of duct wall, 3) resolution of duct lumen, 4) margin of nodule, and 5) internal echoes of nodule. In a blinded fashion, three radiologists graded the quality of images on a 5-point scale.

Results: For reviewer 1/2/3, S showed grade improvements in 1) reduction in the density of shadowing (0.4±0.6/1.1±0.6/0.5±0.5), 2) resolution of duct wall (0.9±0.2/1.5±0.6/1.0±0.5), 3) resolution of duct lumen (0.9±0.2/1.6±0.6/0.7±0.6), 4) margin of nodule (1.0±0.3/1.5±0.5/1.2±0.5), and 5) internal echoes of nodule (1.1±0.3/1.5±0.5/1.2±0.4) and T showed grade improvements in 1) reduction in the density of shadowing (0.4±0.6/1.2±0.6/0.7±0.7), 2) resolution of duct wall (1.0±0.3/1.5±0.6/1.1±0.5), 3) resolution of duct lumen (0.9±0.3/1.6±0.6/0.8±0.6), 4) margin of nodule (1.0±0.3/1.5±0.6/1.2±0.5), and 5) internal echoes of nodule (1.1±0.3/1.5±0.6/1.3±0.4). In all evaluating points, two modes of real-time compound imaging were superior to conventional imaging ($P < 0.05$). There was no significant difference between two modesof compound imaging.

Conclusion: Real-time compound imaging improves evaluation of normal subareolar tissue and subareolar solid nodules compared to conventional ultrasonography by reducing shadowing and increasing anatomic resolution of ducts. **(Journal of Korean Breast Cancer Society 2003;6:15-19)**

Key Words: Breast, US, Breast, Ducts, Ultrasound (US), Ultrasound (US), Technology, Ultrasound (US), Comparative studies

INTRODUCTION

Subareolar area is defined as circular region surrounding nipple in 2cm diameter, and major ductal systems are superimposed in this area. The mature adult female breast is composed of 15 to 25 grossly defined lobes corresponding to parenchyma associated with each of the major ducts that terminate in the nipple with radial arrangement.(*1*) The major ducts are subdivided into collecting ducts, lactiferous sinuses, segmental ducts, and subsegmental ducts. Subareolar area is forbidden area of management because this area is superimposed of ductal and dense fibrous tissue, and difficult to detect and analyze the lesion in radiological and clinical aspects.

Breast ultrasonography can improve the accuracy of clinically and mammographically detected abnormalities. The

Correspondence: Bo Kyoung Seo, Department of Diagnostic Radiology, Konkuk University Hospital, #1 Hwayang-dong, Gwangjin-gu, Seoul 143-914, Korea. Tel: 82-2-450-9654, Fax: 82-2-447-8726, E-mail: ssbk@dreamwiz.com

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subareolar area is often difficult to evaluate ultrasonographically due to tissue shadowing, which obscures visualization of ducts and parenchymal tissue. Real-time compound imaging (RTCI) is the newer ultrasonographic technique and some recent articles have demonstrated the usefulness of RTCI for evaluation of solid breast nodules and breast cancers compared to conventional imaging (CI).(*2,3*) RTCI obtains multiple coplanar images and combines them into a single image in real time. Thus, RTCI improves artifacts by using multiple coplanar images.

The purpose of this study is to determine if RTCI improves evaluation of normal subareolar tissue and solid nodules in subareolar area compared to CI.

MATERIALS AND METHODS

From March 2001 to July 2002, 135 consecutive patients were included in this study. The patient's age ranged 26 to 63 years (mean, 45 years). For prospective study of subareolar area, 190 images scanned both RTCI and CI techniques were used. An HDI 5000 SonoCT (Advanced Technology Laboratories, Bothell, Wash., USA) was used, together with a broad-bandwidth 12-5 MHz, linear scanhead. Breast nodules were scanned by CI first, then by RTCI in the same plane and with the same parameters including magnification, depth, focus, and tissue compression. In each mode, gray-scale gain was adjusted for. Our US equipment can operate in two RTCI modes: survey and target. The former produces three coplanar images, and the latter, nine. In this study, both survey and target modes were used, and scanning was performed by a breast radiologist (B.K.S.). The images of subareolar area, which were obtained with two modes of RTCI and CI, were blindly assessed by three radiologists (J.Y.L., B.K.J., and E.J.C.). The evaluating points of subareolar area were 1) reduction in the density of shadowing, 2) resolution of duct wall, and 3) resolution of duct lumen.

Twenty-two in 135 patients showed solid nodules in subareolar area on ultrasonography. These patients had thirty-three nodules, which were extraductal nodules in 30 and intraductal nodules in three. Tissue sampling was performed with either core-needle biopsy (n=10), or fine-needle aspiration biopsy (n=5). In seven cases in which results of the core-needle or fine-needle biopsy were either positive for malignancy or not definite, surgical excision was performed, as is our usual protocol. A needle biopsy result was considered not definite if the imaging and histopathologic findings were discordant or if needle biopsy results indicated insufficient sampling. Pathologic examination revealed that among the 15, six were fibrocystic change, four abscess, two invasive breast cancer, one ductal carcinoma in situ, one atypical ductal hyperplasia, and one fibroadenoma. In the remaining 18 nodules, follow up ultrasonography was performed at a mean interval of 8.2 months, revealed no interval change, and on the basis of their imaging features we considered these nodules benign. The nodules ranged in size from 5 to 33 (mean, 12.1) mm. Three radiologists blindly evaluated the solid nodules in terms of clarity of margins and internal echoes.

In a blinded fashion, three radiologists graded the quality of images of subareolar area and resolution of solid nodules in subareolar area, which were obtained with survey and target modes of RTCI and CI, on a 5-point scale. The agreement of image interpretation by three radiologists was assessed by kappa coefficients (SAS/STAT software version 6.12; SAS Institute, Cary, NC).

Table 1. Kappa coefficients of three observers in terms of image quality and resolution of solid nodules in subareolar area

Parameters	Kappa coefficients		
	CI	Survey mode of RTCI	Target mode of RTCI
Reduction in the density of shadowing	0.82	0.72	0.74
Resolution of duct wall	0.77	0.83	0.85
Resolution of duct lumen	0.88	0.79	0.77
Clarity of margins of nodules	0.79	0.86	0.88
Clarity of internal echoes of nodules	0.81	0.92	0.90

RTCI = real-time compound imaging; CI = conventional imaging.

RESULTS

The kappa coefficients of three observers in terms of image quality of subareolar area and resolution of solid nodules in subareolar area ranged from 0.72 to 0.92, thus, the agreement of image interpretation was moderate to excellent.

In terms of image quality of subareolar area, grade improvements of survey and target modes of RTCI of three reviewers that; for reviewer 1/2/3, survey mode showed grade improvements in 1) reduction in the density of shadowing (0.4±0.6/1.1±0.6/0.5±0.5), 2) resolution of duct wall (0.9 ±0.2/1.5±0.6/1.0±0.5), and 3) resolution of duct lumen (0.9±0.2/1.6±0.6/0.7±0.6), and target mode showed grade improvements in 1) reduction in the density of shadowing (0.4±0.6/1.2±0.6/0.7±0.7), 2) resolution of duct wall (1.0± 0.3/1.5±0.6/ 1.1±0.5), and 3) resolution of duct lumen (0.9 ±0.3/ 1.6±0.6/0.8±0.6). Thus, two modes of RTCI were superior to CI for evaluation of subareolar area ($P < 0.05$) (Fig. 1).

In terms of resolution of solid nodules in subareolar area, grade improvements of survey and target modes of RTCI were that; for reviewer 1/2/3, survey mode showed grade improvements in 1) margin of nodule (1.0±0.3/1.5±0.5/1.2±0.5) and 2) internal echoes of nodule (1.1±0.3/1.5±0.5/1.2±0.4), and T showed grade improvements in 1) margin of nodule (1.0±0.3/1.5±0.6/1.2±0.5) and 2) internal echoes of nodule (1.1±0.3/1.5±0.6/1.3±0.4). Therefore, two modes of compound imaging were better than conventional imaging for evaluation of solid nodules in subareolar area ($P < 0.05$) (Fig. 2-4).

As compared survey with target modes of RTCI, there was no significant difference between two modes in terms of image quality of subareolar area and resolution of solid nodules in subareolar area ($P > 0.05$).

DISCUSSION

There are histological differences between subareolar and peripheral areas in breast. Subareolar area has superimposition of large major ducts and dense fibrous tissue. Therefore, it's some difficulty to detect and characterize the lesion with clinical breast examination and mammography owing to the histological nature of subareolar area. Additionally, conventional ultrasonography has limitation to evaluate subareolar area because of extensive posterior shadowing caused by abundant fibrous tissue and multiple beam reflections by many major ductal walls. RTCI has a benefit to reduce unnecessary tissue shadowing occurred by Cooper's ligament and fibrous tissue in breast.

The application of compounding principles to RTCI is not new,(*4,5*) but the practical implementation of this technology has only recently been made possible by the substantial computational power of modern, all-digital ultrasound systems. RTCI starts by acquiring multiple frames from different viewing angles. The overlapping frames are then combined to form an RTCI on the display. Compound images can be obtained using a conventional imager, with two modifications. First, the ultrasound beams are steered 'off-axis' from the 90° beams used in CI. Second, the image processor must be programmed to accurately render the steered frames into the appropriate display geometry, and then combine them through frame averaging. This, however, introduces a persistence effect, with the potential for image blurring if the transducer or the many coplanar images. Our US equipment can operate in two RTCI modes: survey and target. The former produces three coplanar images, and the latter, nine. As the number of

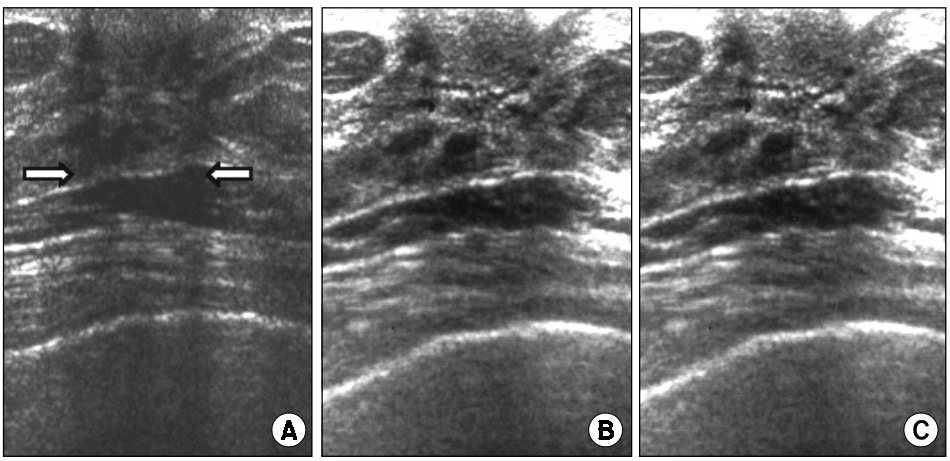

Fig. 1. Conventional ultrasonography (A) shows extensive tissue shadowing in subareolar area. The density of shadowing (arrows) is more decreased on survey (B) and target (C) modes of RTCI. Thus, resolution of duct wall and lumen is improved on both modes of RTCI (B and C).

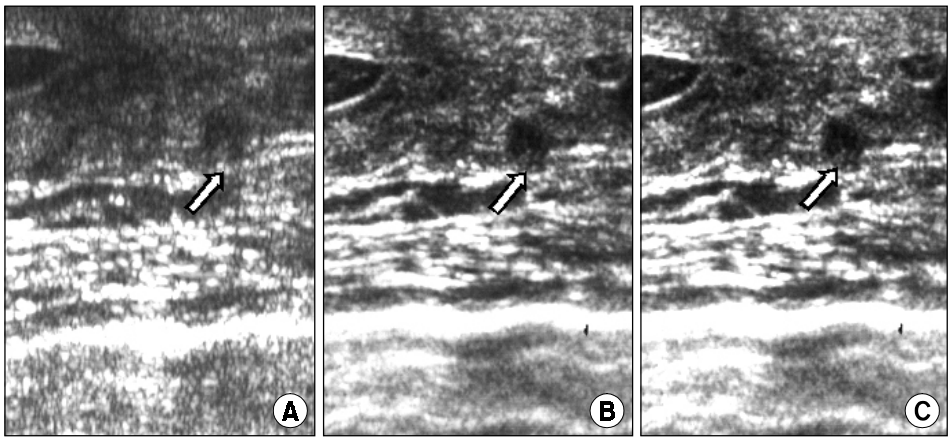

Fig. 2. 39-year-old female with intraductal papilloma. Ultrasonograms show a circumscribed round shaped isoechoic nodule (arrows) in subareolar area. In terms of clarity of margin and internal echoes of nodule, survey (B) and target (C) modes of RTCI are superior to conventional ultrasonography (A).

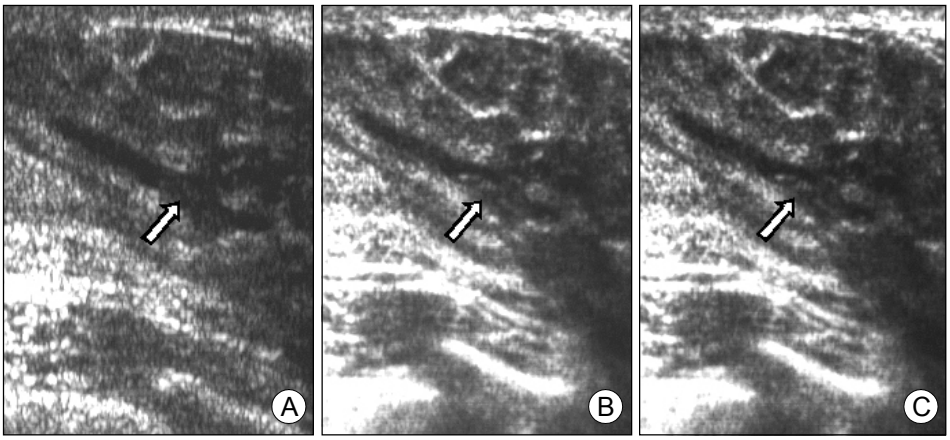

Fig. 3. 33-year-old female with ductal carcinoma in situ. Ultrasonograms show a circumscribed oval shaped isoechoic intraductal nodule (arrows) in subareolar area. Survey (B) and target (B) modes of RTCI are superior to CI (A) for evaluation of the margin and initernal echoes of nodule.

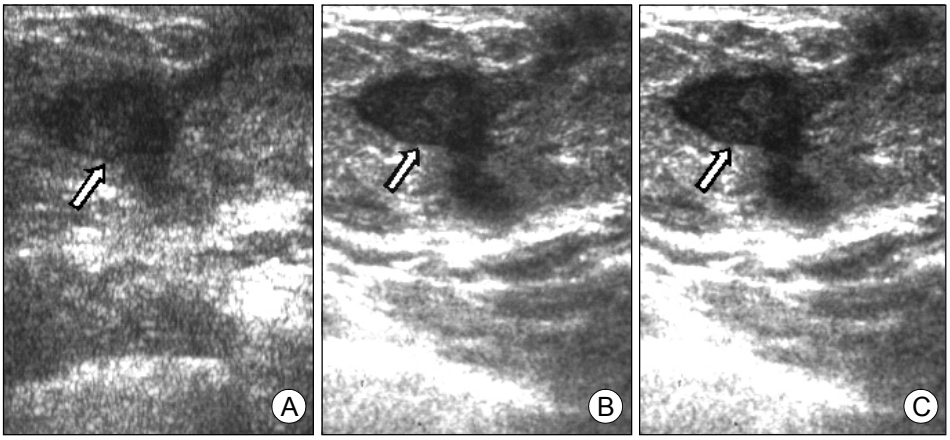

Fig. 4. 28-year-old female with breast abscess Ultrasonograms show an ill-defined oval shaped hypoechoic nodule (arrows) in subareolar area. Survey (B) and target (B) modes of RTCI are superior to CI (A) in terms of clarity of the margin and internal echoes of nodule.

coplanar images are increased, the frame rate is decreased, thus, the image blurring can be occurred in target mode by respiration, a probe, or a movable lesion. In this study, both survey and target modes were used and there was no statistically significant difference between two modes of RTCI. So, the survey mode that uses three coplanar images is enough to use for routine breast examination.

In terms of posterior shadowing, multiple different steered angles are used in RTCI, and posterior echoes are concentrated in a triangular region. Thus, posterior echoes are preserved in the central portion and reduced in the peripheral portion, and overall posterior echoes are less frequent than in

CI. In this study, RTCI effectively reduced the density of shadowing of subareolar area and this result was agreed with the theoretical aspect of RTCI. Reduction of tissue shadowing in subareolar area significantly improved resolution of duct wall and lumen in all three reviewers. Additionally, RTCI was improving the characterization of the solid nodules in subareolar area in this study. We evaluated the margins and internal echoes of the solid nodules and these parameters are important to differentiate benign from malignant solid nodules. The usefulness of evaluation of margins and internal echoes has been reported in many studies.(*6-11*)

By a study of Winchester et al,(*12*) 37% of the breast cancers were located in the upper outer quadrant of the breast, and centrally located tumors (nipple and central locations combined) were 8% in patients with invasive lobular carcinoma, 7% in those with invasive ductal carcinoma, and 8% in combination tumors. The cancers located in subareolar area are commonly impossible to be performed conservation therapy even though early stage and then mastectomy was undergone due to vulnerability of invasion to other lactiferous ducts. In this study, three cases with breast cancer demonstrated better assessment in RTCI than CI. One case with ductal cardinoma in situ and one case with atypical ductal hyperplasia demonstrated intraductal nodule on ultrasonography. In these cases, the lesions were significantly clearly defined on RTCI. Especially, intraductal papilloma is commonly occurred in subareolar area and this tumor is necessary to remove completely due to recurrence and cancerous change. RTCI is superior to evaluate ductal lumen and walls, thus, this might be useful to detect intraductal tumors.

In conclusion, RTCI improves evaluation of normal subareolar tissue and subareolar nodules compared to conventional ultrasonography by reducing shadowing and increasing anatomic resolution of ducts.

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