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ORIGINAL ARTICLE

Evaluation of the role of dynamic 64-MDCT in the characterization and work up of breast cancer ☆

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KEYWORD

64-MDCT breast cancer diagnosis

Abstract *Background:* Imaging of the breast is a vital component not only for breast cancer screening, but also for diagnosis and treatment. Dynamic MDCT has a very promising role as diagnostic tool in breast cancer patients.
Objective: This study aimed to emphasize the role of 64 MDCT in the work up of breast cancer.
Patients and methods: Between October 2012 to April 2014, 100 consecutive patients with suspicious breast lesions underwent bilateral mammography, breast ultrasound and dynamic MDCT. We evaluated the primary lesion morphology, pattern of enhancement with the time enhancement curve, extensions, lymph nodal status, and metastasis in lung or chest wall. Tumor staged based on the TNM classification.
Results: In the studied 100 patients, MDCT detects 107 mass lesions; 64 were malignant and 43 were benign. The collected imaging data were correlated with the surgical and pathologic findings in all patients. Breast dynamic MDCT with the pattern of the time enhancement curve was found to be accurate in diagnosing and lesion characterization, the sensitivity was 93%, specificity was 89%, and accuracy was 91%.
Conclusion: Dynamic MDCT should be considered as a feasible non invasive imaging tool for the diagnosis and work up in patients with breast cancer.

1. Introduction

Breast cancer is the second leading cause of death in women. Early detection is necessary to treat patients and improve their chance for survival (1–3). Imaging of the breast is a vital component not only for breast cancer screening, but also for diagnosis, evaluation, treatment and follow-up (4). Mammography is the standard of reference for early detection of breast cancer (5). Mammography is somewhat less sensitive and less specific in women with dense breasts, in younger women and in women

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on hormone replacement therapy (6). Ultrasound plays a vital role in the assessment of breast masses. In recent years, ultrasound as an adjunct to mammography has improved accuracy in the diagnosis of breast cancer. However, the effectiveness of ultrasound test depends on the operator's level of skill and experience (7). Breast MRI is another excellent diagnostic tool because it has a higher sensitivity compared to mammography; however, there are some drawbacks, such as the cost and lengthy scanning time. Breast MRI is not widely available and some patients cannot do MRIs if they become claustrophobic or have a metallic implant such as a pacemaker (8). Recent studies on the use of computed tomography (CT) technology for breast imaging have refocused the radiology community's attention on the potential benefits of breast CT. Significant advances in technology have enabled breast CT to possibly become another alternative to mammography and MRI for use in breast cancer screening. Breast CT may be more accurate and providing other advantages, such as being less intrusive than mammography and less intimidating than MRI (9). Breast multi-detector CT (MDCT) imagers provide a 3D image of the breast and reduces the superimposition of breast tissue, thus enabling improved tumor detections (10). The main limitations to the breast CT was the high dose of X ray exposure while the use of 64-detector CT machine and low dose techniques reduce these limitations (11).

The aim of this study is to evaluate the role of 64-multidetector computed tomography in the characterization and work up of breast cancer.

2. Materials and methods

2.1. Patients

This study was approved by the ethics committee of our institution during the period between January 2013 to April 2014. It included 100 consecutive female patients with breast lump(s) underwent mammography, ultrasound and MDCT of the breast. The ages of the patients ranged from 28 to 71 years (median ± 49 years). Written informed consent was obtained from each patient prior to the examination and biopsy.

2.2. Inclusion criteria

In this study, cases were referred from the General Surgery outpatient clinic for the assessment of suspected breast lump. Some patients refer to CT examination as there are contra-indication to MRI study, claustrophobic (6 patients) and cardiac pacemakers (3 patients).

2.3. Exclusion criteria

Pregnancy, contra-indications for intravenous contrast, i.e. iodine allergy, renal malfunction and previous allergic reaction to I.V contrast.

2.4. Imaging protocol

1. Bilateral digital mammographic examination (except in case of mastectomy): Standard medio-lateral oblique and cranio-caudal views were taken to obtain a mirror image of both sides.
2. Bilateral breast U/S: Were performed on (Logiq P5, GE Medical Systems, Korea) ultrasound machines with 7.5–12 MHz-linear array transducer.
3. MDCT of the breast using 64-MDCT scanners (Aquilion64; Toshiba Medical Systems Corporation, Otawara, Japan) set with the following parameters: 3-mm thickness, 120 kV, 50–70 mAs, 1-mm slice collimation. Patients were scanned on the supine position; the scan begins from the level of the axilla to the lower edge of the breast, they asked to hold their breath 4 times, before and 1, 3, and 8 min after an IV rapid bolus administration of nonionic contrast material (100 mL) that infused at a rate of 3.0 mL/s.

2.4.1. Post-imaging processing

Multiplanar, MIP and 3D reconstructions were done for the evaluation of mass lesions. All detected lesions reviewed for morphologic features and enhancement pattern. Also, we do the time-density curve by putting the cursor over the solid enhanced part of the lesion and plot the enhancement pattern of the lesion on the 1st three minutes after contrast injection using the software on the workstation. When washout occurs within 1–3 min; it is called rapid washout, while, if washout occurs later than 3 min it is called delayed washout. The curve pattern is classified as; washout, plateau or rising.

2.5. Correlation between radiologic and histopathologic findings

To evaluate the diagnostic accuracy of MDCT in breast masses, correlation with the histo-pathologic results was done for all patients by either FNAB, core biopsy or surgical biopsy. Statistical analysis was performed with the EPR validity test.

3. Results

This study included 100 consecutive female patients with 107 breast lumps, the clinical, radiological as well as pathological findings, all were represented in tables and statistical forms.

3.1. Histopathological diagnosis

Of the 107 lesions, 64 were malignant; IDC was the most frequent malignancy (45/64). Forty three lesions were benign of which fibro-adenoma was the most frequent pathology (33/43) lesions (Table 1).

3.2. Clinical presentation

All patients were complaining of breast lump (s). Axillary L.Ns were palpable ipsilaterally in 37 and bilaterally in 9 patients. Nipple retraction with induration seen in 10 patients. Nipple discharge was the complaint in 32 patients. Follow up of lumpectomy scar done for 5 patients.

3.3. Mammographic diagnosis

According to the primary and secondary signs of malignancy, classification of the lesions was done to a category of benign and malignant; out of 48 lesions that were diagnosed benign

Table 1 Analysis of the 107 lesions with histopathology results.

Histo-pathology	Number of lesions
Invasive duct Ca	45
Paget's disease	6
Invasive lobular Ca	4
Mucinous Ca	4
Papillary Ca	3
Lymphoma	1
Metastases	1
Total malignant lesions	64
Fibro-adenoma	33
Abscess	3
Duct papilloma	5
Normal scar tissue	2
Total benign lesions	43

by mammography: 35 lesions were proved pathologically benign and 13 were false negative (11 with dense breast glandular parenchyma and 2 with small lesions less than 1 cm). On the other hand 59 lesions were diagnosed as malignant by mammography, 51 of them were proved true (+ve) by histopathology and 8 lesions were false (+ve) "5 lesions" with suspected criteria, semi-defined outlines, and 3 lesions showed foci of micro-calcification associated with skin thickening and edema. Poor sensitivity (79%) owing to 11 patients that showed dense breast with poor diagnostic results (Figs. 1–4 and Tables 2, 5 and 6).

3.4. Ultrasonography diagnosis

According to the primary and secondary signs of malignancy, classification of the lesions was done to a category of benign and malignant; out of 44 lesions that were diagnosed benign by U/S.: 33 lesions were proved pathologically benign and 11 lesions were false negative (lesions showed well defined outlines and homogenous texture). On the other hand 63 lesions were diagnosed as malignant by US, 53 of them were proved true (+ve) by histopathology and 10 lesions were false (+ve) "lesions" showed poorly defined outlines, non-homogenous echo pattern, with micro-calcification foci (Figs. 1–4 and Tables 2, 5 and 6).

64-MDCT diagnosis of breast mass based on analyses of the morphological parameters as well as the dynamic post-contrast data: All detected lesions were classified as either benign or malignant lesions.

(a) Morphologic parameters:

The presence of irregular shape with speculated margin was a sign of malignancy. This was statistically significant with $p < 0.0001$, and out of 61 lesions that showed ill-defined margin and diagnosed by MDCT as malignant 59 were proved to be malignant histopathologically. The 2 false (+ve) ill-defined enhancing lesions were abscesses. The smooth lobulated margin was not a sign of benignity, as out of 48 lesions showed smooth lobulated margin: 32 lesions diagnosed benign by MDCT, 19 were proved to be benign histopathologically and 3 were false (−ve) with pathological result as mucinous carcinoma. The other 10 lesions were malignant by MDCT and proved pathologically.

MDCT was superior in micro-calcification detection, (23 cases) while in mammography, 16 cases shown micro calcification that was seen in only 9 patients by U/S. The detailed morphological analysis of all lesions was shown in Table 3.

(b) Dynamic post-contrast study:

Timing of enhancement and the pattern of enhancement were used for lesion characterization; early, peripheral and heterogonous enhancements were seen mainly in malignant lesions.

3.5. Time density curve patterns

The washout and plateau patterns were seen mainly in malignant lesions.

According to all collected dynamic MDCT data, out of 42 lesions that were diagnosed benign, 38 lesions were proved pathologically benign and 4 were false negative. On the other hand 65 lesions were diagnosed as malignant 60 of them were proved true (+ve) by histopathology and 5 lesions were false (+ve) (Figs. 1–4 and Tables 4–6).

3.6. Signs of spread of malignancy (staging)

64 MDCT was found to be superior to mammography and U/S as an efficient technique in the preoperative assessment and staging of breast masses.

Surgical decisions for 5 patients were changed from lumpectomy to mastectomy because of the additional information provided by dynamic MDCT (Table 5).

The most accurate modality in detecting, diagnosing and staging breast lesions was the 64 MDCT with 91% accuracy (Table 6).

4. Discussion

Diagnostic procedures are crucial for the early detection of breast cancer that accounts for approximately 15% of female cancer death (12).

In this work all patients were complaining of breast lump (s) with palpable axillary L.Ns in 46 patients. Breast cancer is often first suspected when a lump or change in the breast is found (13). The most common symptom of breast cancer is a new lump or mass (14). Kolb et al. stated that a lump detected either by the patient or by a physician carries a 20% risk of cancer (15).

Mammography results calculation revealed 79% sensitivity, 81% specificity and 80% accuracy for mass characterization. The relatively low sensitivity was due to the non-informative dense breast in 11 patients. Dense breast tissue can look white or light gray on a mammogram. This can make mammograms harder to interpret (13). Mukhtar et al. stated that breast mammography detected 78% of cancer in glandular breast (16), while Badgwell et al. gave a lower sensitivity of 50% with a specificity of 40% which is attributed to several factors including: Patient age, breast density, tumor size and location (17). On the other hand Manisha et al. found that mammography sensitivity was 100% and specificity was 97.9%, (18). The

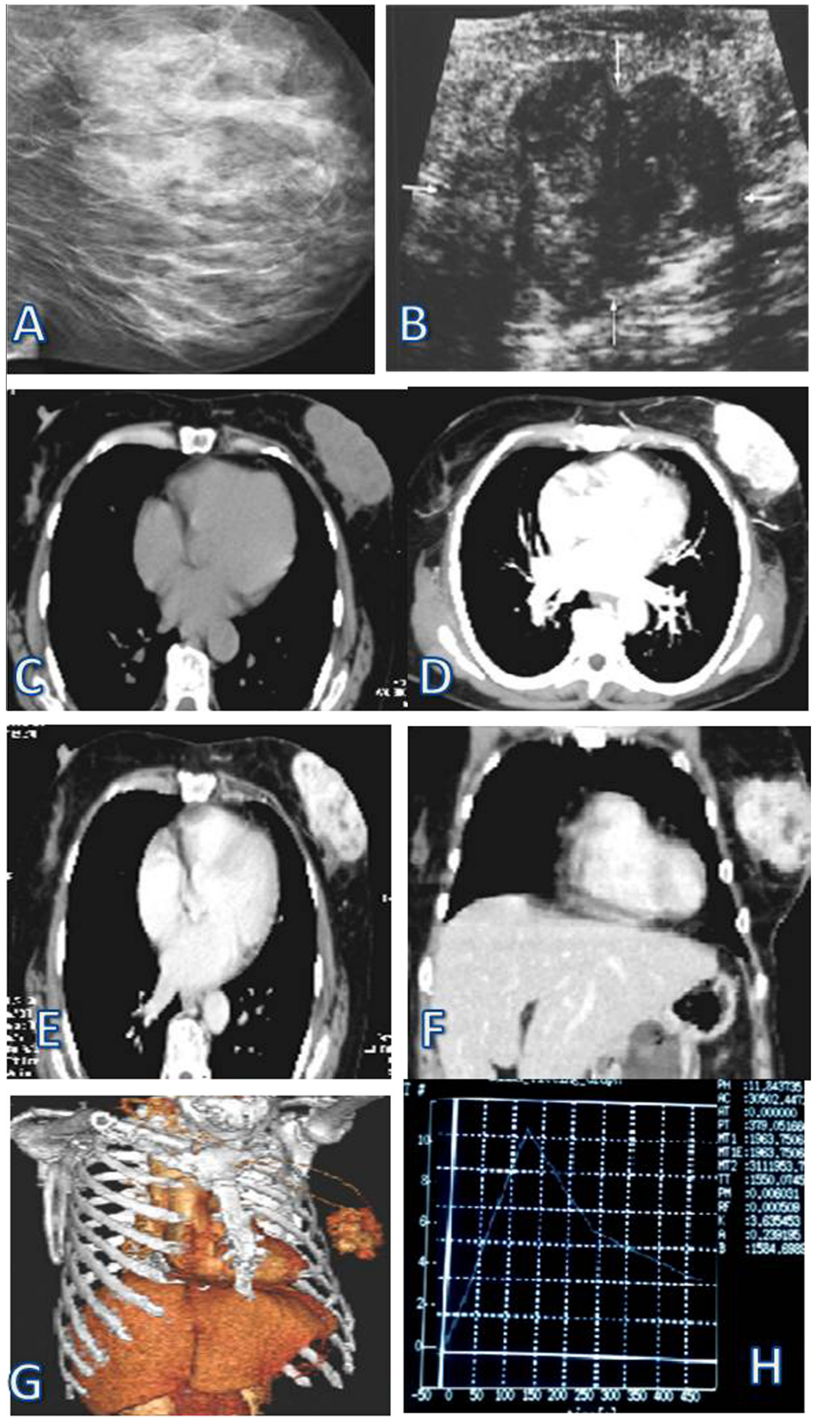

Fig. 1 59-year old female patient, complaining from painless left breast mass. (A) Mammography MLO view shows glandular parenchyma with poor definition. (B) Lt. breast US shows hypo-echoic soft tissue mass with well-defined lobulated outlines, echofocal-lesion. (C–E) Axial CT (pre and +C after 1 and 3 min) shows sizable Lt. Br. mass with smooth micro-lobulation, early heterogeneous enhancement at 1 min and rapid washout of contrast at 3 min. (F) Coronal (+C) CT showed enhanced mass with no other lesions detected. (G) 3D images show the enhanced lesion with its vascular supply and angiogenesis. (H) Malignant pattern time density curve (washout). Histopathology: invasive duct carcinoma.

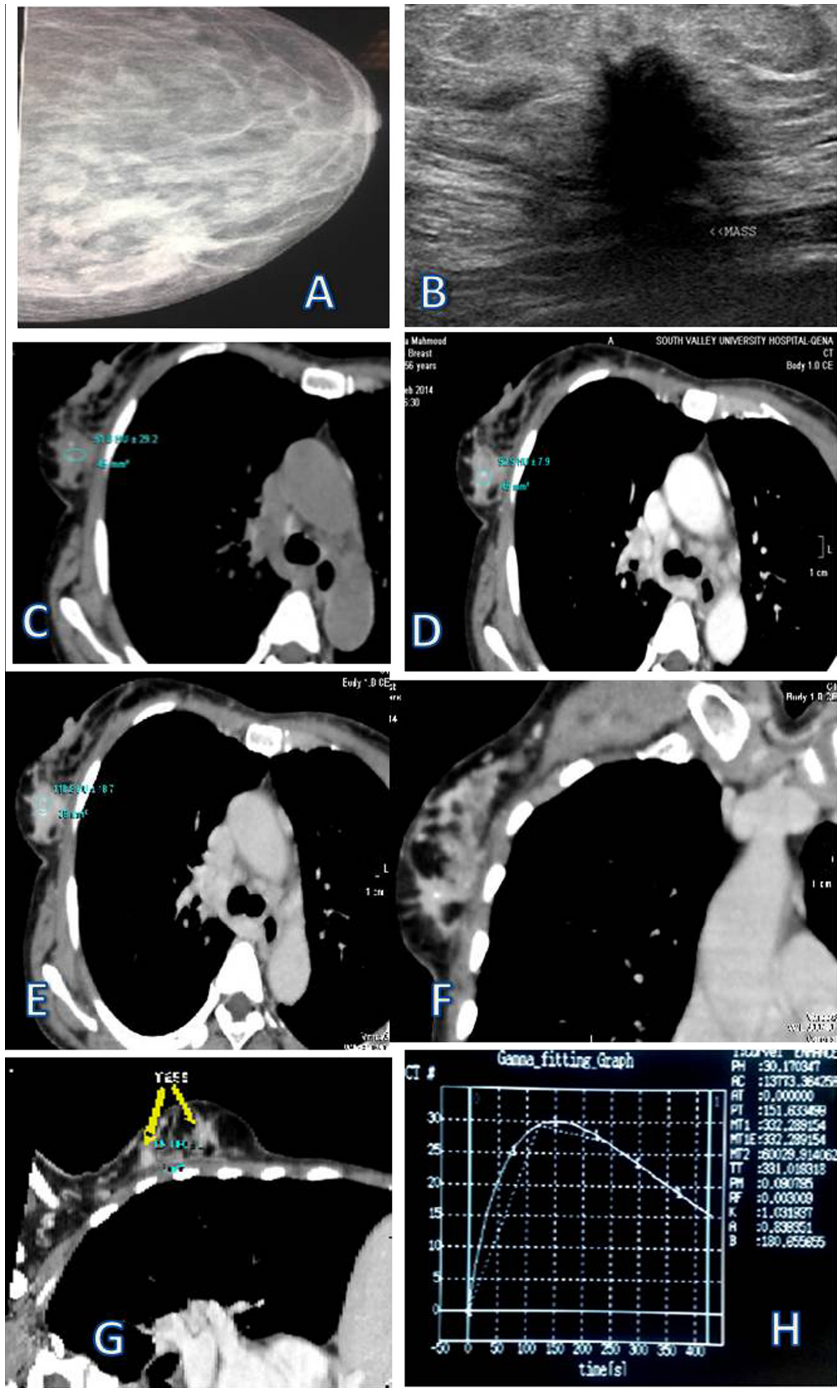

Fig. 2 47-year old female patient, complaining from rapidly growing mass at the right breast. (A) Mammography MLO view shows ill-defined hyper-dense shadows suspicious of malignancy. (B) US breast shows poorly defined hypo-echoic oblong shaped lesion with posterior shadowing and irregular outlines. (C–E) Axial (pre and +C, 1 and 3 min) CT shows Rt. breast mass with micro-calcifications, at the non contrast image and early mild enhancement at 1 min with persistence of the contrast at 3 min image. (F) Coronal (+C) shows another focal lesion with speculated margin. (G) Oblique (+C) shows the two enhanced nodular masses with speculated outlines mainly at the larger lesion. (H) Time density curve shows plateau pattern. Histopathology: multifocal invasive lobular carcinoma.

analysis of our US results revealed that the overall diagnostic sensitivity was about 82%, specificity was 77% and accuracy was 80%. Sorin et al. found that US sensitivity was about 88% (19). Michell depicted US sensitivity of 87%, specificity of 92% and accuracy of 89% (20). The sensitivity, specificity, positive predictive value and negative predictive value for US were 95%, 94.1%, 95.5%, and 93.75% respectively (21).

We preferred 64 MDCT technique with low dose parameters: This was comparable with Diana et al., who recommended using examination protocols based on setting using

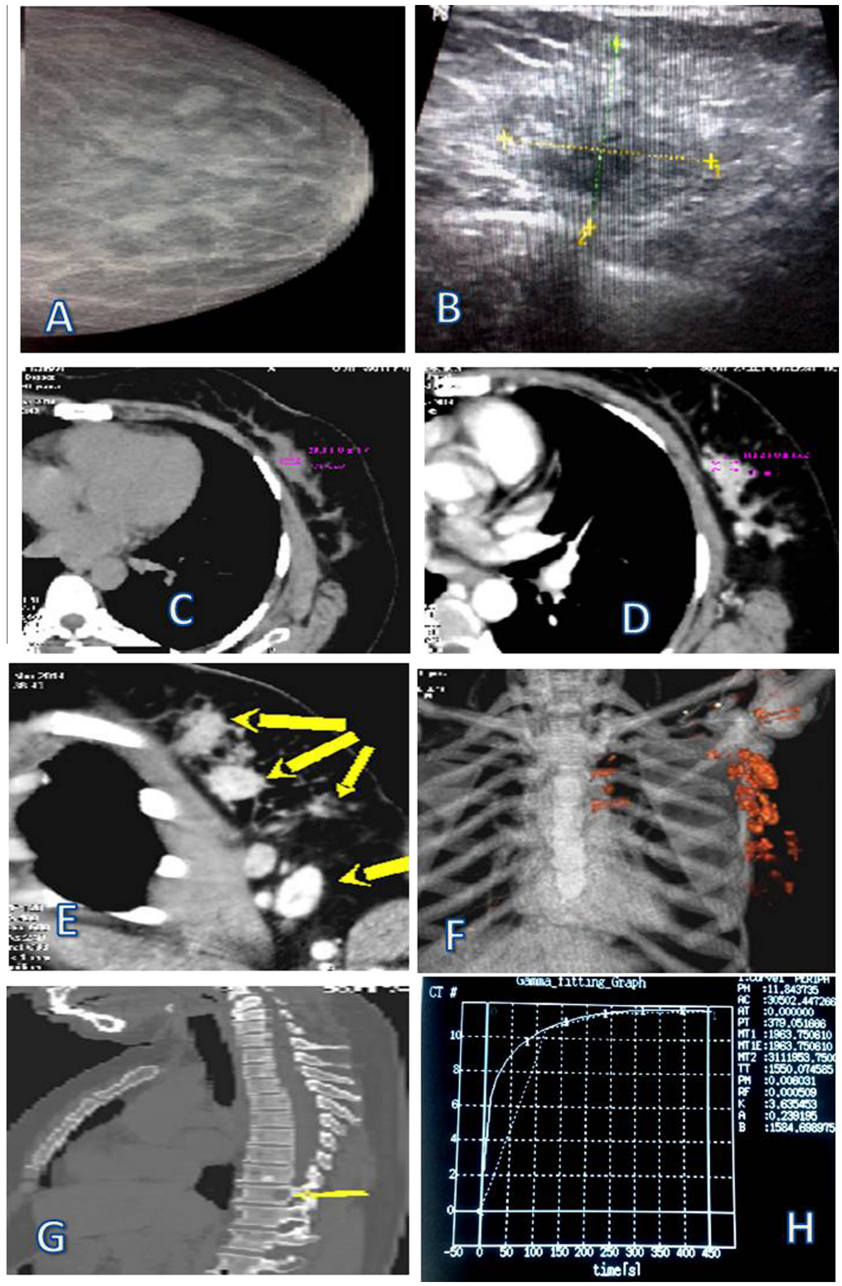

Fig. 3 51-year old female patient complaining from palpable painless masses in Lt. breast: (A) Mammography, CC view showed well-defined small dense nodular opacities/no calcifications. (B) Lt. breast U/S showed well-defined hypoechoic mass lesions with multiple atypical axillary LNs. (C–E) Axial 64-MDCT (pre, 1 and 3 min +C) shows Lt. breast irregular nodular lesions with persistent dense contrast enhancement. (F) 3D image and (G) sagittal image dorsal spine (bone window) showed abnormal bone marrow texture with lytic bony lesion (arrowed). (H) Time density curve plateau pattern. Histo-pathology: breast lymphoma with nodal and marrow infiltrations.

modulation for dose reduction to the female breast and pelvis (22) Low dose MDCT scanning is a feasible imaging technique for tumor staging before treatment (11). A preliminary study using low-dose breast CT by Seo et al., demonstrated satisfactory results for breast cancer staging by low dose CT (23).

According to results of this study, MDCT morphologic data established that the presence of irregular shape with speculated margin as a sign of malignancy. Non-contrast MDCT was found to be superior to mammography and U/S in the detection of micro-calcification, (23 cases) with MDCT versus 16 and 9 by mammography and U/S respectively. Micro-calcification is a hallmark of breast cancer (24). Inoue et al. found that a speculated margin had a positive predictive value for malignancy of 99% (25).

This study results documented that in dynamic post-contrast MDCT study, early, peripheral and heterogonous enhancement was seen mainly in malignant lesions. The wash-out and plateau pattern of the time density curve were seen

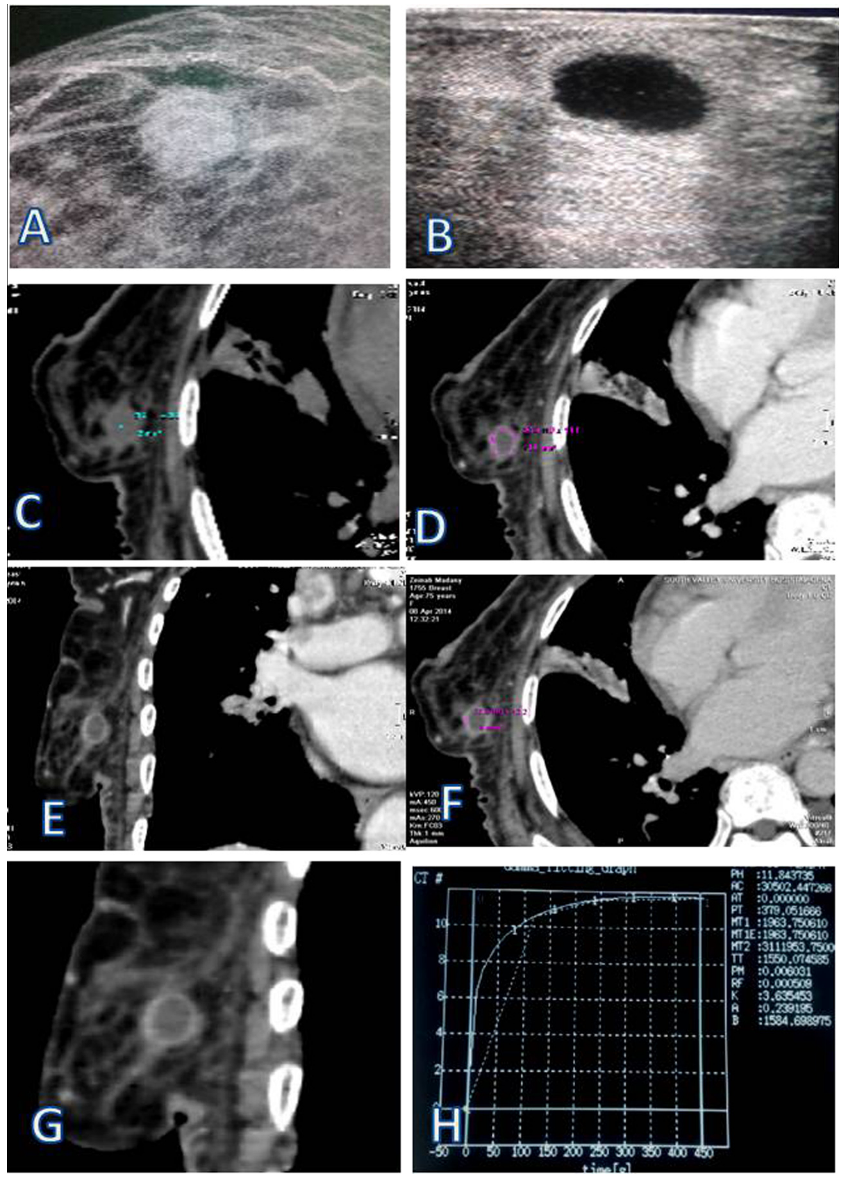

Fig. 4 61-year old female patient with history of Lt. mastectomy for breast cancer, complaining of Rt. breast lump: (A) Mammography magnified MLO view: shows rounded dense suspicious shadow with irregular outlines. (B) Breast U/S shows anechoic cystic lesion with thick irregular inner walls. (C) Non-contrast axial CT showed Rt. breast focal lesion with irregular outlines. (D) Dynamic (+C) Axial CT showed cystic lesion with peripheral enhancement. (E) Coronal (3 min +C) CT shows persistent delayed enhancement. (F) Axial (8 min +C) CT shows persistent delayed mild enhancement. (G) Zoomed (+C) coronal CT showed the cystic lesion with rim enhancement and related hyper-vascularity. (H) Time density curve with benign pattern (persistent). Histopathology: benign breast abscess.

Table 2 Analysis of the primary diagnose by mammography and U/S compared to histo-pathologic results.

Diagnostic modality	Malignant	Benign
Mammography	59 (51 true and 8 F +ve)	48 (35 true and 13 F −ve)
US	63 (53 true and 10 F +ve)	44 (33 true and 11 F −ve)
Histo-pathology	64	43

Table 3 Morphological analysis of the all lesions in non-enhanced MDCT.

Morphology analysis	Non-enhanced MDCT
Mass lesion	
1. Number	
–Solitary	94
-Multiple	6
2. Wall definition	
–Well-defined	46
–Ill-defined	61
3. Border	
–Lobulated	48
–Speculated	59
Calcifications	
–Macro	19
–Micro	23
Secondary signs	
–Skin thickening	27
–Nipple changes	13

mainly in malignant lesions. Dynamic MDCT overall sensitivity was 93%, specificity was 89% and accuracy was about 91%. This is in agreement with Fujita et al. who concluded that strong enhancement on 1-min images is caused by the neo-angiogenesis typical of malignant lesions (26) and with Takase et al. who found that early enhancement was indicative sign of malignancy with sensitivity of 92% but specificity was only 64% (27). The washout or plateau pattern was a predictor of likelihood of carcinoma. Rim enhancement is highly predictive for malignancy (28,29). The dynamic helical CT-mammogram study of Yamamoto et al. (29) showed 94.6% sensitivity, 58.6% specificity, 74.7% positive predictive value, 89.4% negative predictive value and 78.9% overall accuracy (31). MDCT confirmed a sensitivity, specificity, and accuracy of 61%, 88% and 71% whereas MRI confirmed a sensitivity, specificity and accuracy of 75%, 88% and 80%, respectively (1).

Results in this series showed that MDCT was superior to mammography and U/S. For the pre-operative detection of breast tumors and depiction of tumor invasion; surgical decision for 8 patients were changed because of the additional diagnostic information of dynamic MDCT. We prefer examining the patients by MDCT in the supine position for surgical simulation. These results were coincidence with Lee et al. (11) who stated that: to stage the breast cancer (TNM stage), we should evaluate lymph nodes in the internal mammary, supra or Infra clavicular areas, and axillae. Mammography or ultrasonography was limited in evaluating these lymph nodes (22). Also, Lim (2003) concluded that, for tumor staging of invasive breast cancers, we should evaluate breasts, lymph nodes and other organs that were frequent metastatic sites, such as bones, liver, or lungs (30).

Preoperative MDCT can be performed with the patient in the supine position that facilitates simultaneous localization

Table 4 Analysis of the primary diagnose according to morphological and contrast enhancement findings of dynamic MDCT compared to histo-pathologic results.

Diagnostic item	No of malignant lesions	No of benign lesions
Morphology	61	46
Pattern of enhancement	3	28
Homogenous patchy	11	9
Peripheral	51	5
Time of enhancement		
Early	61	5
Late	4	37
Time density curve		
Washout	40	–
Plateau	25	18
Rising	–	24
Primary diagnosis by DMDCT (total)	65 (60 true and 5 false +ve)	42 (38 true and 4 false −ve)
Histo-pathology diagnosis	64	43

Table 5 Criteria for malignancy spread for cancer staging in dynamic MDCT, mammography and U/S.

Findings	No. of lesions in MDCT	No. of lesions in mammography	No. of lesions in US
Multicentric lesions	4	1	2
Multifocal lesions	2	1	1
Pectoral muscle and chest wall invasion	3	1	–
-axillary LN	59	37	57
-others, (supra-clav.-internal mammary, hilar and mediast.)	9	–	3
Bony cage lesions	2	–	–
Lung nodules	3	–	–
Liver focal lesions	2	–	–

Table 6 Statistics of diagnostic accuracy of different imaging modalities.

Imaging modality	Mammography (%)	Ultrasonography (%)	64 MDCT (%)
Sensitivity	79	82	93
Specificity	81	77	89
Accuracy	80	80	91

of the lesion and evaluation of its extent with examination of the skin and chest wall as well as the lymph nodes. Therefore 3D MDCT should be considered an accurate preoperative imaging technique (27). Surgical plans for six patients were changed because of the additional information provided by MDCT (26).

5. Conclusion

According to the results of this study we concluded that dynamic MDCT is recommended to be as a feasible non invasive accurate imaging tool for the diagnosis and work up in breast cancer patients.

Conflict of interest

We have no conflict of interest to declare.

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