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Ductal Carcinoma In Situ: Comparison of Mammography, Ultrasonography, and MRI in the Evaluation of Disease Extent

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Ductal Carcinoma In Situ: Comparison of Mammography, Ultrasonography, and MRI in the Evaluation of Disease Extent

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Abstract

PURPOSE

The purpose of this study is to determine relative accuracy of mammography (MMG), ultrasonography (US), and magnetic resonance imaging (MRI) in patients with ductal carcinoma in situ (DCIS) as compared with pathology finding.

MATERIALS AND METHODS

Institutional review board approval was obtained with waiver of informed consent. Between January 2001 and December 2008, 91 women with 97 lesions of DCIS or microinvasive ductal carcinoma underwent MMG, US, and MRI preoperatively. The size of lesions was measured by each radiologist on each imaging modality and these finding was compared with pathologic result. We arbitrarily decided to use the same percentage-30% of the longest diameter-as described by the World Health Organization for comparison with physical examination. We defined lesion size on image as equal to that at pathology if the longest diameter was within 30% of the size at pathology. The imaging technique size was defined as an equal if it was within the range from 70% to 130% of the pathology size, an underestimate if it was less than (70% of) the size at pathology and an overestimate if it was greater than (130% of) the size at pathology. If the lesion was not visualized on imaging technique, it was regarded as underestimates. Agreement-disagreement rates for sizes at MMG, US, and MRI were compared with size at pathology using intraclass correlation coefficient (ICC). The tendencies of all methods to underestimate or overestimate the size were tested using the Wilcoxon's signed rank test.

RESULTS

The mean lesion diameter was 2.93 cm (range, 0.2~11 cm). MRI enabled identification of DCIS in 96 (99.0 %) of the 97 lesions. US detected DCIS in 93 (95.9 %) of the 97 lesions and MMG detected DCIS in 84 (86.6 %) of the 97 lesions. Microcalcifications were seen in 61 of 97 lesions (62.9 %) on MMG. MRI showed best reliability with pathologic finding (ICC=0.909, p=0.000) than US (ICC=0.779, p=0.000) and MMG (p=0.617, p=0.000). Agreement about the extent of DCIS as measured by MMG, US, and MRI compared with pathology was 65.0 %, 60.8 %, and 41.2 %, respectively. MRI complied with pathologic finding more often. When there was disagreement between imaging and pathologic size, MRI had the significant tendency to overestimate (p=0.000).

CONCLUSION

MRI appears to provide the better correlation with pathology than MMG and US in patients with DICS. However, MRI had the tendency to overestimate the extent of DCIS than US and MMG. Index terms: Ductal carcinoma in situ, Mammography, Sonography, Magnetic resonance imaging

Abbreviations:

DCIS = ductal carcinoma in situ US = ultrasonography MMG=mammography MRI = magnetic resonance imaging

Advances in Knowledge:

1. MRI agreed with pathologic finding significantly than other modalities, regardless of microcalcifications.

2. MRI appears to provide better correlation with pathology than mammography and US in patients with DCIS.

Implications for patient care:

1. MRI appears to provide better correlation with pathology than mammography and US in patients with DCIS.

Introduction

Before the advert of widespread mammographic screening, DCIS was rarely detected, accounting for only 0.8% to 5.0% of all breast cancer [1], but after the widespread use of mammographic screening in asymptomatic women, DCIS accounts for up to 30% of breast cancer in screening population and approximately 5% of breast cancer in symptomatic women [2-4]. The increase in DCIS detection by screening has been cited as contributing to the decrease in breast cancer mortality [5].

Currently, the demand for breast conservation

treatment is increasing. However, in patients who received breast conservation treatment, the overall survival rate is significantly lower when the surgical margins are positive for tumor cells then that of the surgical margins are negative [6]. Therefore, accurate evaluation of the tumor extent is important when breast conservation treatment is considered [7, 8].

At mammography, 62%-98% of DCIS lesions are detected owing to the presence of calcifications [9-11]. Although most cases of DCIS lesions are diagnosed mammographically, 6%-23% of DCIS lesions are not visible at MMG [9-13]. Furthermore, tumor extent of approximately 15-20% of cases are underestimated at MMG because of noncalcified DCIS [14].

At US, 44%-95% of DCIS lesions are detected [15-19]. To our knowledge, the accuracy of sonographic estimation of DCIS extent had not been evaluated in English literatures. Because this entity usually becomes manifest as a pure calcification on MMG [9-11].

At MRI, 20%-95% of DCIS lesions are detected [13, 18, 20-30]. Because of contrast enhancement, MRI can overestimate extent of DCIS if there are benign proliferative lesions adjacent to DCIS lesion. It is not well known about the accuracy of DCIS by MRI [31-35].

There have been few studies comparing pathological size of DCIS with MRI size [8, 36-40]. Toour knowledge, there is no published report on comparing pathological size of DCIS with mammographic size, sonographic size and MRI size. The purpose of this study was to determine relative accuracy ofMMG,US, and MRI in patients with DCIS as compared with pathologic findings.

Materials and Methods

Institutional review board approval was obtained with waiver of informed consent.

Between January 2001 and December 2008, total 511 DCIS or microinvasive ductal carcinomas in 507 women were diagnosed at operation in our institution. Retrospective review of medical records during a 96-month period revealed 96 women with 102 lesions of pure DCIS (n=77) and microinvasive ductal carcinoma (n=25) who underwentMMG,US, and MRI before operation.

All women underwent bilateral MMG, whole breastUS, and contrast enhanced MRI of the breasts preoperatively. The sequence of imaging examinations of these patients was as follows: all patients underwent MMG followed by US and then US-guided core biopsy with histologic diagnosis of DCIS or microinvasive ductal carcinoma. After the histologic diagnosis of DCIS or microinvasive ductal carcinoma, bilateral whole breast MRI was performed before operation. There may be questions about the accuracy of the tumor dimension of the given modality (MMG,US, MRI) and whether the tumor had changed in size if the imaging studies were performed at different times. So, we excluded one patient who underwent MRI before 6 months of the operation. Remaining patients underwentMMG,US, MRI within 4 weeks of the operation.

Multifocality, defined as two or more areas of DCIS within the same ductal system and/or quadrant of within 5 cm of the primary lesion [15], was seen in 4 patients and they were excluded in this study due to difficulty of exact measurement in given modality and histopathology.

Therefore, the remaining 97 lesions in 91 women were the subject of this retrospective study. The age of the patients ranged from 26 to 75 years (mean age 47 years).

Among 91 patients in this study, the indication for performing breast MRI was extent evaluation of DCIS for work up of breast-conserving therapy.

The lesions manifested as a clinically occult lesion in 70 patients (76.9%), a palpable mass in 16 patients (17.6%), and nipple discharge in 6 patients (6.6%).

MMG was used as the gold standard for the presence of microcalcification. In our study, microcalcifications were seen in 61 of 97 lesions (62.9%).

Imaging techniques

Bilateral MMG in two standard image planes, i.e. the craniocaudal (CC) and mediolateral oblique (MLO) views, was performed with a Senographe DMR scanner (GE Medical Systems,Milwaukee,WI,USA) or a Performa scanner (Instrumentarium Corp,Tuusula,Finland) with additional views being obtained as necessary.

Three radiologists performed a bilateral whole-breast sonography on all patients on whom US was performed with 5-12-MHz transducers on an HDI-3000, HDI-5000 (all, Philips Medical Systems), or IU-22 (Philips Medical Systems,Bothell,Wash,USA). We usually performed a bilateral whole-breastUS, not a targeted US to MMG or clinical findings. The usual time to complete a bilateral whole-breastUSexamination was 15 to 30 minutes.

The MRI examination was performed using a 1.5-T unit (Intera, **Philips** Medical Systems, Best, Netherlands or Signa, GE Medical Systems,

Milwaukee, WI, USA) with dedicated breast coil with the patient in the prone position. Weobtained fat-saturated axialT2-weighted **image (T2WI)** and axial dynamic 3D T1-weighted images (T1WI) before and after the IV administration of gadolinium (Magnevist, BayerShering Healthcare, Berlin, Germany) of 0.15 mmol/kg with injection rate2 mL/sec. Sixcontrast-enhanced sequences were performed by an early series at 90 seconds and followed by a latest series at 7 minutes. Post-processing manipulationincluded subtraction images and maximum-intensity-projection images.

In Intera, the image parameters were TR/TE = 6700/74; flip angle 90°; field of view (FOV) 300, matrix 250 x 384, number of excitation (NEX) 2; section thickness/gap 5/1 in fat-suppressed T2WI, and TR/TE 4.42/1.49; flip angle 12°; FOV 300; matrix 361 x 384; NEX 1; thickness/gap 1.5/0 in dynamic 3D T1WI.

In Sigma, TR/TE = 4,000/85, flip angle 90°, FOV 240, matrix 256 × 224, NEX 2, section thickness/gap 3/0.1 in fat-suppressed T2WI; TR/TE = 625/12, flip angle 90°, and TR/TE = 6.2/3.1, flip angle 10°, section thickness 2.6; FOV 300, matrix 256 × 192, NEX 1.5 in dynamic T1WI.

Analysis

MMG,US, and MRI were separately evaluated by three radiologists with extensive experience in breast imaging. The consensus of the three radiologists as present was considered positive.

In MMG, mass lesions, asymmetric opacities, architectural distortion, and malignant microcalcifications were considered positive findings. The MMG appearances were evaluated with regard to lesion size, parenchymal pattern, presence of obscured margin, presence of microcalcifications, and distribution of microcalcifications.

In US, nodules and echogenic spots without acoustic shadowing that suspicious correspond to microcalcifications were considered positive findings [41]. TheUSappearances were evaluated with regard to lesion size, presence of nodule, presence of echogenic spots, presence of posterior shadowing, echogenicity, and margin of the nodule.

In MRI, size, morphology [42] and kinetics [43] were evaluated for all enhancing lesions. Enhancement in contiguity that corresponds with findings of MMG or US was considered suspicious for DCIS regardless of size, morphology, and kinetics. Enhancement in continuity with the primary tumor, lesions smaller than 5 mm with at least 70% increase in signal intensity within the first 90 seconds of contrast material injection, regional areas of enhancement with at least 60% increase in signal intensity within the first 90 seconds after contrast material injection, segmental or linear clumped enhancement were considered suspicious for DCIS, regardless of kinetics [44].

We analyzed the MMG, US, and MRI for lesion detectability and lesion extent. The lesion size was measured as the maximal diameter in each modality, and we evaluated the accuracy of demonstrated lesion extent. For the lesions detected in modality, we determined the difference in size between the imaging modality and pathologic result.

Because there is no standard method by which to compare the size of tumor on imaging with the size of tumor at pathology [31, 44-45], we arbitrarily decided to use the same percentage-30% of the longest diameter-as described by the World Health Organization for comparison with physical examination, like Yeh et al. [46]. We defined lesion size on imaging as equal to that at pathology if the longest diameter was within 30% of the size at pathology. The imaging technique size was defined as an equal if it within the range from 70% to 130% of the pathology size, the imaging technique size was defined as an underestimate if it was less than (70% of) the size at pathology and an overestimate if the imaging size was greater than (130% of) the size as determined at pathology. If the lesion was not visualized on imaging technique, it was regarded as underestimate.

Statistical Methods

Agreement-disagreement rates for size atMMG,US, and MRI were compared with size at pathology using intraclass correlation coefficient. The tendencies of all methods to underestimate or overestimate the size were tested using the Wilcoxon's signed rank test where an underestimate was scored as -1 and an overestimate was scored as 1.

Statistical analyses were performed by using commercially available software programs,SPSS for Windows (version 12; SPSS,Chicago,Ill). Significance levels were determined by the Bonferroni correction for multiple comparisons ($p \leq 0.05/3$).

Results

The pathologic size of the lesion ranged from 0.2 to 11 cm in the longest diameter with a mean of 2.93 ± 0.41 cm. The mean size of mammographic lesion, sonographic lesion and MRI lesion are 3.27 ± 0.51 cm, 2.55 ± 0.33 cm, and 3.42 ± 0.47 cm, respectively.

Of the 91 patients, 40 patients had a unilateral mastectomy, 46 patients had a unilateral

breast-conserving operation (BCO), 4 patients had a bilateral BCO, and 1 patient had a unilateral mastectomy and contralateral BCO. .

Pathologic results showed 73 sites of DCIS and 24 sites of microinvasive ductal carcinoma in 91 women. At histologic analysis, the nuclear grade of the lesions were classified as low (n=9), intermediate (n=60), and high (n=28).

Many patients had dense breast tissues on MMG. According to American College of Radiology BI-RADS parenchymal pattern [47], of the 97 lesions, density was pattern 4 (dense breasts) in 19 (19.6%), pattern 3 (heterogeneously dense parenchyma) in 56 (57.7%), pattern 2 (breasts with minimal scattered fibroglandular density) in 21 (21.6%), and pattern 1 (fatty breasts) in 1 (1.0%).

The 84 of 97 (86.6%) lesions were depicted on MMG. Of the 84 lesions, 20 lesions (23.8%) were as a mass with calcifications, 41 lesions (48.8%) were evident as calcifications only, and 23 (27.4%) were as a mass without calcification. Thirteen lesions were not visible at all on MMG due to dense breast parenchyma.

Microcalcifications were seen in 61 of 97 sites (62.9%) on MMG. The most common distribution of microcalcifications was clustered in 27 of 61 (44.3%) lesions, followed by segmental in 21 (34.4%) lesions. Remaining 13 lesions showed regional in 11 (18.0%) and diffuse in 2 (3.3%).

MMG underestimated lesion size in 32.0% and overestimated lesion size in 26.8% (p=0.508) (Table 1).

Thirty-one lesions were underestimated on MMG. Of these underestimated lesions, 11 lesions was not detected on MMG due to dense breast parenchyma, and two of them were pathologically very small, less than 5 mm in size. Five lesions showed mass in dense breast causing difficulty of accurate measurement of lesion size. And two lesions were underestimated because tumor size on MMG differed from that on pathology because of threshold difference (we arbitrarily chose 70% difference in size and these patients had a difference in size of 68.2% and 66.7%, respectively).

Of the 26 lesions in overestimated lesion size, one lesion was underlying dense breast, four lesions were associated benign proliferative breast lesions adjacent to DCIS, and one lesion was pathologically very small, 2 mm in size. Seven lesions were overestimated due to extensive calcifications which were not associated with DCIS. And four lesions were classified as an overestimate likely because of the arbitrary criterion of 130% (we arbitrarily chose 130% difference in size and these patients had a difference in size of 136%. 139%, 140% and 140%, respectively).

Given a known MMG findings, US can depict breast abnormality in 93 of 97 (95.9%) lesions. All of these 93 lesions were proved DCIS or microinvasive ductal carcinoma after core biopsy. Of the 93 lesions seen on US, 43 lesions (46.2%) as a mass, 39 lesions (41.9%) as a mass with echogenic spots, and 11 lesions (11.8%) as echogenic spots without acoustic shadowing that correspond to microcalcifications. Of the 43 mass lesions, 39 lesions (90.7%) showed as irregular shape, and 7 lesions (16.3%) as oval shape. Ten of 43 lesions (23.3%) showed as microlobulated margin, 4 (9.3%) as circumscribed margin, 20 (46.5%) as indistinct margin, and 9 (20.9%) as angular margin. Twenty-nine lesions showed hypoechogeneicity (67.4%) and 12 lesions (27.9%) showed mixed echogeneicity and remaining 2 lesions (4.7%) showed isoechogenicity.

US underestimated lesion size in 24.7% and overestimated lesion size in 14.5% (p=0.105) (Table 1).

For the 24 lesions in underestimated lesion size, 17 lesions with echogenic spot or indistinct or spiculated margins caused difficulty of accurate measurement of lesion size. In two of 24 lesions, benign proliferative breast lesion was associated adjacent to DCIS. Five lesions had a difference in size measurement as % that was classified as an underestimate likely because of the arbitrary criterion of 70%. In four lesions, they were regarded as underestimates because US was unable to determine the extent of microcalcifications. All of these four lesions had microcalcifications on MMG and they were not seen on US.

Of the 14 lesions in overestimated lesion size, 8 lesions with echogenic spot or indistinct or spiculated margins caused difficulty of accurate measurement of lesion size and two lesions were pathologically less than 5 mm. In one of 14 lesions, there was atypical papilloma adjacent to DCIS. Two lesions had a difference in size measurement that was classified as an overestimate likely because of the arbitrary criterion of 130%.

The 96 of 97 (99.0%) lesions were depicted on MRI. Of the 96 lesions seen on MRI, 53 (55.2%) lesions were identified as mass enhancement and 43 (44.8%) lesions were identified as nonmass enhancement. Of the lesions evident as masses on MRI, 35 of 53 (66.0%) lesions were irregular shape and 18 (34.0%) lesions were round shape. Of the non-mass like enhanced lesion on MRI, 41 of 43(95.3%) had segmental nonmass-like enhancement, and 2 (4.7%)

had regional nonmass-like enhancement. Among the 96 lesions with MRI-detected DCIS, visual assessment of lesion kinetics was performed in all 96 lesions. 52 of 96 (54.2%) lesions were delayed washout kinetics, 37 (38.5%) were plateau, and 7 (7.3%) were progressive.

MRI underestimated lesion size in 4.2% and overestimated lesion size in 30.9% (p=0.000) (Table1). MRI had the largest number of equal estimation for pathology than other modalities (Fig 1).

Of the four lesions in underestimated lesion size, one lesion was 2.2 cm in the longest diameter pathologically but occult on MRI.

Of the 30 lesions in overestimated lesion size, 9 lesions had a difference in size measurement that was classified as an overestimate likely because of the arbitrary criterion of 130%. Sixteen lesions with nonmass-like enhancement caused difficulty of accurate measurement of lesion size. Two lesions were pathologically small size less than 5mm. Four lesions had benign proliferative lesion or high-risk lesion adjacent to DCIS.

Nuclear grade was available for all 97 lesions. Low nuclear grade was present in 9.4% of MRI-detected DCIS, 7.1% of MMG-detected DCIS, and 9.7% of US-detected DCIS (p>0.05). Intermediate to high nuclear grade was present in 95.7% of US-detected DCIS, 90.6% of MRI-detected DCIS, and 92.9% of MMG-detected DCIS (p>0.05). There was no significant difference in the nuclear grade of DCIS found by given modalities.

According to the pathologic report, 16 lesions of DCIS were associated with adjacent benign proliferative breast lesions or high-risk lesion such as fibrocystic change, sclerosing adenosis, columnar cell-change, mucocele-like lesion, lobular carcinoma in situ, intraductal papilloma, atypical papilloma and atypical ductal hyperplasia. Four of 16 (25%) lesions caused overestimation of lesion size at MRI. One lesion causedUSoverestimation, and four lesions caused MMG overestimation.

According to the report of MMG, 75 lesions (77.3%) were in dense breast parenchyma. MMG showed better reliability with pathology when the lesion without dense breast (ICC=0.843, p=0.000) than with dense breast (ICC=0.586, p=0.000). US and MRI showed no significant difference reliability with pathology according to parenchyma pattern (ICC=0.881, p=0.000; ICC=0.759, p=0.000 in US and ICC=0.875, p=0.000; ICC=0.912, p=0.000 in MRI).

Microcalcifications were seen in 61 of 97 sites (62.9%) on MMG. MMG showed better reliability with pathology when the lesion with microcalcification (ICC=0.612, p=0.000) than without microcalcification (ICC=0.540, p=0.001). US showed better reliability with pathology in the lesion without microcalcification (ICC=0.846, p=0.000) than with microcalcification (ICC=0.696, p=0.000). MRI showed relatively high reliability with pathology regardless of presence of microcalcification (ICC=0.921, ICC=0.897, p=0.000).

Discussion

DCIS is a noninvasive carcinoma where malignant cells line the duct with an intact basement membrane. If detected before invasion occurs, the cure rate is nearly 100 % [8, 48]. Because of the widespread use of mammographic screening in asymptomatic women, DCIS accounts for up to 30 % of breast carcinoma in asymptomatic screening population and approximately 5 % of breast carcinoma in symptomatic women [2-4]. Around 95 % of cases of DCIS are now detected in their preclinical, asymptomatic phase by mammographically visible microcalcification [49-50]. The increase of the DCIS detection by screening has been cited as contributing to the decrease in breast cancer mortality [5]. Although the relationship between DCIS and invasive cancer may be variable, there is evidence to suggest that approximately 30-50 % of all DCIS progresses to invasion, explaining the benefit derived from the treatment of DCIS [48].

Breast conserving therapy is used prevalent for the treatment of early stage breast cancer [6, 8]. Harris et al. describe lumpectomy and radiation therapy as reasonable for the treatment of DCIS within 3 cm in size [51]. Rosner et al. demonstrated that patients who underwent wedge resection had equivalent outcomes to those who underwent mastectomy for DCIS [52]. However, among patients who received breast-conserving therapy, the overall survival rate is significantly lower when surgical margins are positive for tumor cells then surgical margins are negative [6]. The positive surgical margin is usually the result of inadequate resection of the cancer's intraductal component [53-54]. Therefore, accurate evaluation of the tumor extent is important when breast conservation treatment is considered [7-8].

At MMG, 62%-98% of DCIS lesions are detected owing to the presence of calcifications, with 2%-23% manifesting as simply a mass or asymmetric density [9-11]. Although most cases of DCIS lesions are diagnosed mammographically, 6%-23% of DCIS lesions are not visible at mammography [9-13]. More accurate imaging assessment of lesion extent is necessary for successful breast conservation. The extent of DCIS cannot always be accurately predicted

with MMG [23, 28]. The tumor extent is often underestimated with MMG [24].

MMG size is currently the standard method for estimating pathological size before operation. However, underestimation occurs in approximately 15-20% of cases [14]. Possible explanations for underestimation are that not all cases of DCIS calcify. The detection of DCIS by MMG largely depends upon the presence of calcifications. DCIS found on MMG is calcified in approximately 90% of cases [9, 11]. Some areas of DCIS can be completely noncalcified and some sites of DCIS can contain calcification in only part of the tumor. This limits the ability of MMG to detect and accurately stage the extent of DCIS.Hollandand Hendriks carried out whole-organ studies on a series of 119 mastectomies. They concluded not be interpreted as two separate foci, but rather a large tumor where the two mammographically identified fields are connected by DCIS which is mammographically invisible due to the lack of detectable size calcifications [55].

The absence of calcification in DCIS is also supported by the fact that in its invasive form only 30-40% of ductal carcinoma is associated with mammographically evident calcifications [56]. Because DCIS is considered to be preinvasive form of ductal carcinoma [57], unless ductal carcinoma loses its calcifications when it becomes invasive, the bulk of DCIS does not form calcifications. Therefore the inability to detect most uncalcified DCIS suggests that MMG is unable to identify most sites of DCIS. In addition, in those lesions seen on MMG, the inability to detect noncalcified DCIS of MMG can lead to underestimation of tumor size [58]. We also found such a trend.

In our study, MMG underestimated lesion size in 50% and overestimated lesion size in 26.5% (p=0.129. Among given modalities (MMG,US, and MRI), MMG showed most large number of underestimation. In contrast, one case with extensive calcifications due to adjacent benign proliferative breast lesion caused overestimated extent by MMG.

The presence of dense tissue on MMG contributed to less lesion extent agreement than MRI compared with pathology; similar to that previously by other [8, 13, 46]. In our study, of the 14 of 17 sites in underestimated lesion size and 4 of 9 sites in overestimated lesion size showed dense breast with/without irregular margins or speculation causing difficulty of accurate measurement of lesion size.

Little is known about theUSfeatures and accuracy of DCIS because this entity usually manifests as pure mammographic calcifications, which, to our knowledge, have rarely been evaluated with US.

Of the 29 sites seen on US, the most common sonographic feature of DCIS was hypoechoic lesion (91.7%) with microlobulated margin (37.5%), irregular shape (62.5%) and normal acoustic transmission (45.8%). The findings in our study concur with other study [41, 59] and confirm that when evident on sonography, DCIS appears most frequently as a solid, irregular mass with microlobulated margins and without posterior acoustic enhancement or shadowing.

Breast US is considered mandatory in the evaluation of the mammographically dense breast in all age [60]. The role of bilateral whole-breast US as a screening tool has also recently been addressed in the literature [61-62]. US have not been considered an acceptable screening modality because of the poor detection of microcalcifications, an important feature of DCIS [63-64]. However, other recent reviews have detected the majority of calcifications with a high frequency probe [42, 65-66].

At US, 44%-95% of DCIS lesions are detected [15-19].USdetection (85.3%) of DCIS is less than that mammographic detection (88.2 %) of DCIS in our study. The findings in our study concur with other study [15, 45, 68-69]. US detection of DCIS is also less than MRI detection (88.2%) of DCIS like another study [44].

In our study, US underestimated lesion size in 41.2% and overestimated lesion size in 20.6% (p=0.289). Although the number of underestimation is largest, there were no statistic significance (p>0.05). Limited ability for detection of DCIS contributed to less lesion extent agreement than MRI compared with pathology, like other studies [63-64]. For the six of 14 sites in underestimated lesion size and four of seven sites in overestimated lesion size showed echogenic spot or indistinct margins caused difficulty of accurate measurement of lesion size. In five lesions, US did not depict lesion. However, all of these lesions were depicted on MMG as microcalcifications.

MRI has been documented to be capable of depicting approximately 100 % of invasive carcinomas [18, 20-23, 69-70]. However, the ability of MRI to detect DCIS is reported to be limited. The reported sensitivities of MRI for detection of DCIS have varied widely, ranging from 20 % to 95% [13, 18, 20-30]. The wide ranges in sensitivities are likely due to variations in interpretation, imaging parameters that are used by different investigators, as well as selection bias. In our study, the detectability of DCIS was higher with MRI (88.2%), MMG (88.2%) than with US (85.3%). MRI

underestimated lesion size in 23.5% and overestimated lesion size in 26.5% (p=0.129). Although MRI had the largest number of equal estimation for pathology than other modalities (50%), four sites of DCIS are not depicted with MRI; therefore, MRI alone may be insufficient. Two of four sites were less than 0.5 cm in longest diameter. However, 1 cm and 2.2 cm sized lesions were not identified with MRI, suggesting that tumor size alone is not responsible for false-negative results. Shiraishi et al. considered that MMG is able to depict lesions if microcalcifications exist, and that demonstration with MRI is related not only to lesion size, but also to the amount of tumor cells and the signal behavior of contrast enhancement [8]. We also found such a trend.

However, MRI is also prone to error because DCIS is often found in the setting of benign proliferative lesions, such as sclerosing adenosis, atypia, and proliferative fibrocystic change, which also enhance on MRI. Thus, where DCIS ends and proliferative changes begin can be difficult to determine. Because of increased proliferation and angiogenesis, benign proliferative lesions showed enhancement on MRI [22, 25, 29, 31-32]. Kumar et al. reported that MRI enhancement dose reflect underlying biologic changes, and, all of the false-positive MRI cases showed moderate- to high-risk proliferative fibrocystic changes. Such proliferative changes have been associated with a significant increase in the risk of malignant transformation compared with normal breast epithelium. When MRI enhancement overestimated the size of DCIS, usually in the setting of ER-positive non-high-grade DCIS, they also found moderate- and high-risk proliferative changes [31]. In our study, one of nine sites in overestimated lesion size had benign proliferative lesion adjacent to DCIS.

Of the 30 sites seen on MRI, the most common MRI feature of DCIS was irregular enhancing mass with irregular shape or segmental nonmass enhancement (23.3%). If the ductal pattern is not identified, DCIS is often indistinguishable from a benign lesion with MRI [8, 71]. So we considered non-ductal pattern in our cases caused difficulty of accurate measurement of lesion size.

Kinetic analysis of enhancement pattern was not found to be helpful in our study, Among the 30 sites with DCIS detected by MRI, visual assessment of lesion kinetics was performed in 25 sites. In 16 of 25 sites (64%), washout kinetics was demonstrated and five (20%) showed plateau kinetics. However, four of 25 sites (16%) showed progressive kinetics, supporting the result of Viehweg et al. [29, 37], who reported that although DCIS lesions demonstrate enhancement, “typical” malignant curves were not present.

There was no appreciable difference in the nuclear grade of DCIS found by MMG or MRI [37]. In our study, there was no significant difference in the nuclear grade of DCIS found by given modalities (MMG,US, MRI).

Several reports have been published regarding the comparing sensitivity for detection of DCIS between MMG and US [59, 67-68]. A few studies have been published regarding the comparing sensitivity for detection of DCIS between MMG and MR [8, 13]. Berg et al. reported that sensitivity for depiction of DCIS by MMG, US and MRI was 55%, 47%, 89%, respectively [44]. However, toour knowledge, there is no published report about comparing pathological size of DCIS with MMG size,USsize and MRI size.

In our study, MRI size estimations are well correlated with those based on pathologic examinations, given the very different methods for size estimation of each technique. Also, MMG showed better agreement with pathology when the lesion without dense breast, and with microcalcifications. Our study suggests that not only is MRI capable of detecting more sites of DCIS than MMG and US, but the size of the lesions discovered by MRI is larger, perhaps more accurately indicating the extent of the duct that is involved [37]. However, MRI had the tendency to overestimate the extent of DCIS than other modalities.

The primary limitation of our study was retrospective study with relatively small number of patients. The second limitation is that some of our results reflect the patient selection in our study population. Women without MRI are not included. This study is based on a patient population with known breast carcinoma. The third limitation is that US was performed without being blinded to MMG or clinical findings, and MRI was performed without being blinded to MMG, clinical, or US findings. This artificially inflates the performance of supplemental imaging.

The results from our selected group of patients suggest that in women with known or suspected DCIS, determination of the presence and extent of disease may be best established with complemented MRI. If breast conservation treatment is being considered, MRI may be helpful in identifying the sites of DCIS that would otherwise be unapparent and whose presence would change surgical treatment to wider excision or mastectomy. However, further work with a larger series of women, and long-term follow-up are needed to determine the value of MRI in detecting DCIS and determining the extent of this disease.

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Illustrations

Illustration 1

Table 1. MMG, US, and MRI extent compared with pathologic extent in 97 sites of 91 patients.

Table 1. MMG, US, and MRI extent compared with pathologic extent in 97 sites of 91 patients.

Estimation of Imaging Technique	Pathology Extent Versus		
	MMG[a]	US[b]	MRI[c]
Under	31(32.0)	24(24.7)	4(4.2)
Equal	40(41.2)	59(60.8)	63(64.9)
Over	26(26.8)	14(14.5)	30(30.9)

Numbers in parentheses are percentages.

[a]In thirteen patients, the lesions were not visualized on MMG, these cases were regarded as underestimation.

[b]In four patients, the lesions were not visualized on US, these cases were regarded as underestimation.

[c]In one patient, the lesion was not visualized on MRI, this case was regarded as underestimation.

Illustration 2

Figure1. A 45-year-old woman with incidental MMG abnormality in the Rt breast. MMG shows 1 cm sized pleomorphic clustered calcifications in upper portion of the Rt breast (ellipse). US hsows a hypoechoic lesion with suspicious calcifications in upper portion of the Rt breast (solid arrow). MRI shows 3.5 cm sized segmental ninmass-like enhancement in upper portion of the Rt breast (solid arrows). Pahtologic result was a 3 cm sized DCIS.