

## Diagnosis of Tis/T1 Breast Cancer Extent by Multislice Helical CT: A Novel Classification of Tumor Distribution

Mitsuhiro Tozaki,\* Makio Kawakami,\*\* Masafumi Suzuki,\*\* Ken Uchida,\*\*\*  
Akinori Yamashita,\*\*\* and Kunihiko Fukuda\*

**Purpose:** To evaluate the clinical usefulness of multislice helical CT (MSCT) for assessing breast cancer extent.

**Materials and Methods:** MSCT was performed in 70 patients with Tis/T1 breast cancer [12 ductal carcinoma *in situ* (DCIS) and 58 invasive carcinoma]. The distribution pattern of contrast enhancement (CE) was classified into five categories: solitary lesion (localized area of CE), grouped lesion (satellite: localized CE with linear and/or spotty enhancement; crowded: clustered spotty enhancement), separated lesion (multifocal foci of CE), mixed lesion (grouped lesion with multifocal foci), and diffuse lesion (diffuse CE).

**Results:** Solitary lesion was seen in five cases of DCIS, 27 invasive carcinomas without intraductal spread (IDS), six invasive carcinomas with IDS, and one multicentric cancer. Grouped lesion was seen in six DCIS and 15 invasive carcinomas with IDS. Separated lesion was seen in one case of invasive carcinoma and fibroadenoma, and three multifocal/multicentric cancers. Mixed lesion was seen in two multicentric cancers. Diffuse lesion was seen in one case of DCIS and three invasive carcinomas. The coincident rate between MSCT pattern and histologic distribution was 85.7% (60/70). In solitary and grouped lesions, accuracy for the detection of tumor extent with a deviation of less than 2 cm in length was 91.7% (55/60).

**Conclusion:** MSCT is extremely accurate in the diagnosis of IDS and the multicentricity of breast cancer.

**Key words:** breast cancer, tumor extent, multislice helical CT

### INTRODUCTION

SEVERAL RANDOMIZED TRIALS ON stage I and stage II breast cancers have found no significant difference in the overall or disease-free survival rates between total mastectomy and breast conservation surgery (BCS).<sup>1,2</sup> The attainment of negative surgical margins is the most significant predictor of local control after BCS.<sup>3</sup> To avoid local recurrence caused by residual tumor, it is important to obtain precise information regarding the extent and distribution of the breast cancer. Helical CT has been

applied to breast cancers for the accurate determination of cancer extent<sup>4-7</sup> and 3D display prior to surgical planning.<sup>6</sup> Multislice helical CT (MSCT), first clinically available in 1998, enables faster scanning time, a wider area of scan coverage, and higher resolution of the volume data than single helical CT. The purpose of this study was to evaluate the clinical usefulness of MSCT for assessing breast cancer extent using our original classification of tumor distribution.

### MATERIALS AND METHODS

#### Patients

From November 1999 to August 2001, MSCT was performed in 137 patients with pathologically proved breast cancer. All patients provided informed consent before undergoing MSCT. The study group consisted of 70 consecutive Tis/T1 breast cancers among these

Received April 21, 2003; revision accepted June 21, 2003.

Departments of \*Radiology and \*\*Pathology, Jikei University School of Medicine, \*\*\*Department of Surgery, Daisan Hospital, Jikei University School of Medicine

Reprint requests to Mitsuhiro Tozaki, M.D., Department of Radiology, Jikei University School of Medicine, 3-25-8 Nishi-Shimbashi, Minato-ku, Tokyo 105-8461, JAPAN.

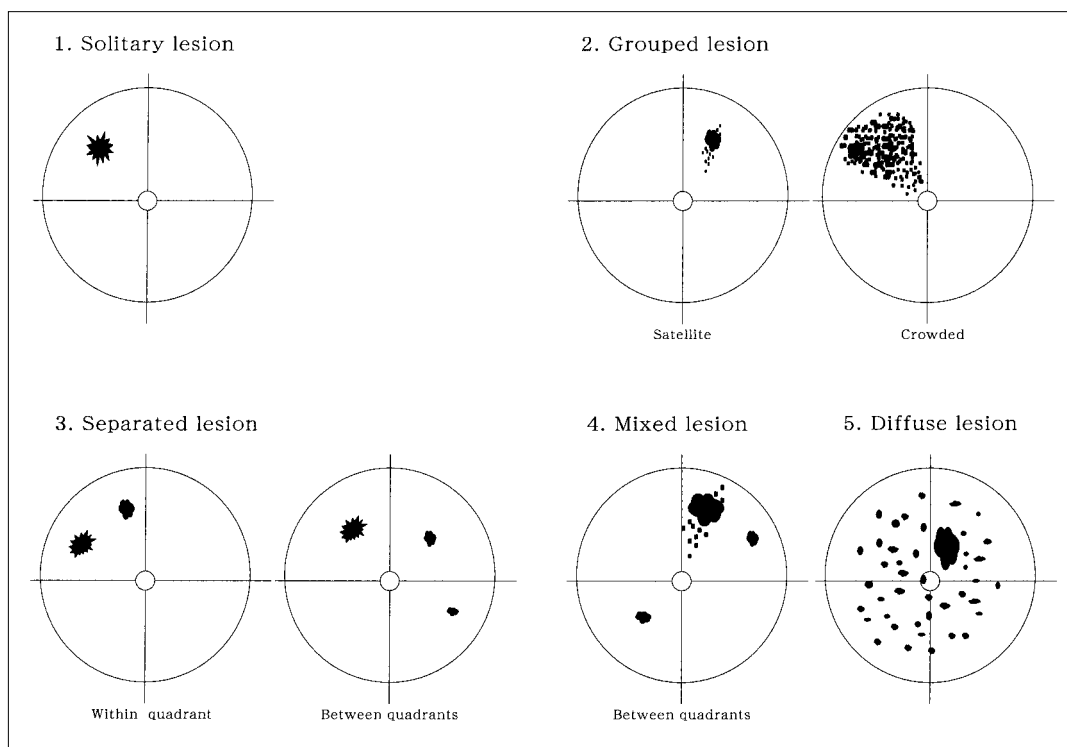


Fig. 1. Distribution pattern of enhancing lesions as determined by MSCT.

patients. This included 12 ductal carcinomas *in situ* (DCIS), and T1 58 invasive carcinomas. Subjects were 69 women and one man, with a mean age of 56 years (range, 31-81 years).

#### CT protocol

An MSCT scanner (SOMATOM Volume Zoom; Siemens Medical Solutions, Erlangen, Germany) with four detector bands was used. Patients were examined in the oblique supine position, the same as in the surgical position. Dynamic CT covering the whole breast and axilla was performed with 100 mL of nonionic contrast material (Iopamiron 370; Nihon Schering K.K., Osaka, Japan) at an injection rate of 4 mL/sec. The first scan was started 30 sec after commencing contrast injection (first phase). The second scan was started at a 70-sec delay from the start of the injection (second phase). The third scan was started at a 5-min delay from the start of the injection (late phase). First-phase images were scanned in 10 sec with four detector rows, 2.5-mm collimation, 500-msec rotation speed, and a pitch of 3. Second-phase and late-phase images were scanned in 20-25 sec with four detector rows, 1-mm collimation, 500-msec rotation speed, and a pitch of 4-5.

From the raw data of second and late phases obtained with 1-mm collimation, image data of 1.25-mm effective thickness was generated with 40% overlapping. Multiplanar reformations (MPR), parallel to the thoracic

wall, were done for visualization of breast cancer extent. In some cases of widespread intraductal component, maximum intensity projection (MIP) was also done.

#### Distribution pattern of contrast enhancement by MSCT

All MSCT images were assessed by one experienced radiologist (M.T.) who had been masked as to the mammographic and ultrasonographic findings. A lesion was defined as positive if an asymmetrically focal enhancement was detected in the second-phase MPR images of the bilateral breasts. Symmetric enhancement was defined as negative (normal or mastopathy).

The distribution pattern of contrast enhancement (CE) was retrospectively classified into five categories (Fig. 1): solitary lesion (localized area of CE), grouped lesion (satellite: localized CE with linear and/or spotty enhancement; crowded: clustered spotty enhancement), separated lesion (multifocal foci of CE), mixed lesion (grouped lesion with multifocal foci), and diffuse lesion (diffuse CE). Two or more separate foci of CE within the same quadrant were defined as "within quadrant." Two or more separate foci in different quadrants were classified as "between quadrants."

#### Histopathologic evaluation of tumor extent

For mastectomy cases, serial sections were obtained from the main tumor, and BCS specimens were sliced into 5-mm contiguous sections. Excisional margins were

evaluated, and cancer foci at the margin were classified as positive.

In the TNM classification, Tis is defined as DCIS, and T1 is defined as an invasive tumor smaller than 2 cm. Intraductal extension and multifocal and multicentric tumors were recorded in accordance with the TNM system. Intraductal spread (IDS) was classified in three categories by the length from the edge of the index tumor: IDS1: intraductal component is less than 1 cm, IDS2: intraductal component is 1-2 cm, IDS3: intraductal component is more than 2 cm. Two or more separate foci of cancer within the same ductal network and/or quadrant were defined as multifocal. Two or more separate foci in different quadrants were classified as multicentric.

#### MSCT and pathologic correlation

Histologic tumor distribution was classified into five categories, the same as the MSCT classification. The coincident rate between the MSCT pattern and histologic distribution was assessed. In grouped lesions, tumor extent was calculated. In the satellite grouped pattern, the length of linear and/or spotty enhancement from the edge of localized CE was measured. In the crowded grouped pattern, the size of clustered spotty enhancement was measured based on the largest diameter. The length and size of the CE lesion measured on MSCT was compared with those determined histologically, and the deviation of the MSCT findings was evaluated.

## RESULTS

#### Histopathologic characteristics

Mastectomy was performed in 24 patients and BCS in 46. Only two cases showed a positive margin (4.3%). Histopathological diagnosis was 12 DCIS, 56 invasive ductal carcinomas, one mucinous carcinoma, and one medullary carcinoma. The mean size of DCIS was 29.2 mm (range, 4-75 mm). The mean size of invasive carcinoma was 15.6 mm (range, 5-20 mm). Table 1 shows the intraductal component, multifocality, and multicentricity of the tumors.

#### Distribution pattern of contrast enhancement by MSCT

MSCT enabled visualization of all 70 breast cancers. The distribution patterns of enhancing lesions are shown in Table 2. Solitary lesions detected by MSCT included six invasive carcinomas with IDS and one multicentric carcinoma. The later lesion was invasive ductal carcinoma with separate focus of 2-mm-sized DCIS, identified in mastectomy specimens. The satellite grouped pattern was seen in four DCIS and 12 invasive carcinomas with IDS. The crowded grouped pattern was

**Table 1. Intraductal component, multifocality, and multicentricity**

DCIS	12
Invasive carcinoma without IDS	29
Invasive carcinoma with IDS1	5
Invasive carcinoma with IDS2	9
Invasive carcinoma with IDS3	8
Multifocal tumor	1
Multicentric tumor	6

**Table 2. Distribution pattern of MSCT and histologic findings**

Solitary lesion (n=39)	
DCIS	5
Invasive ductal carcinoma	26
Medullary carcinoma	1
Invasive ductal carcinoma with IDS1	3
Invasive ductal carcinoma with IDS2***	3
Multicentric carcinoma*	1
(Invasive ductal carcinoma with separate focus of DCIS)	
Grouped lesion: satellite (n=16)	
DCIS**	4
Invasive ductal carcinoma with IDS1	2
Invasive ductal carcinoma with IDS2	6
Invasive ductal carcinoma with IDS3	3
Mucinous carcinoma with IDS3*	1
Grouped lesion: crowded (n=5)	
DCIS	2
Invasive ductal carcinoma with IDS3***	3
Separated lesion: within quadrant (n=1)	
Multifocal carcinoma	1
Separated lesion: between quadrants (n=3)	
Invasive ductal carcinoma <sup>a)</sup>	1
Multicentric carcinoma	2
Mixed lesion: between quadrants (n=2)	
Multicentric carcinoma	2
Diffuse lesion (n=4)	
DCIS	1
Invasive ductal carcinoma <sup>b)</sup>	1
Invasive ductal carcinoma with IDS3	1
Multicentric carcinoma	1

\*Underdiagnosis more than 2 cm in length, n=2

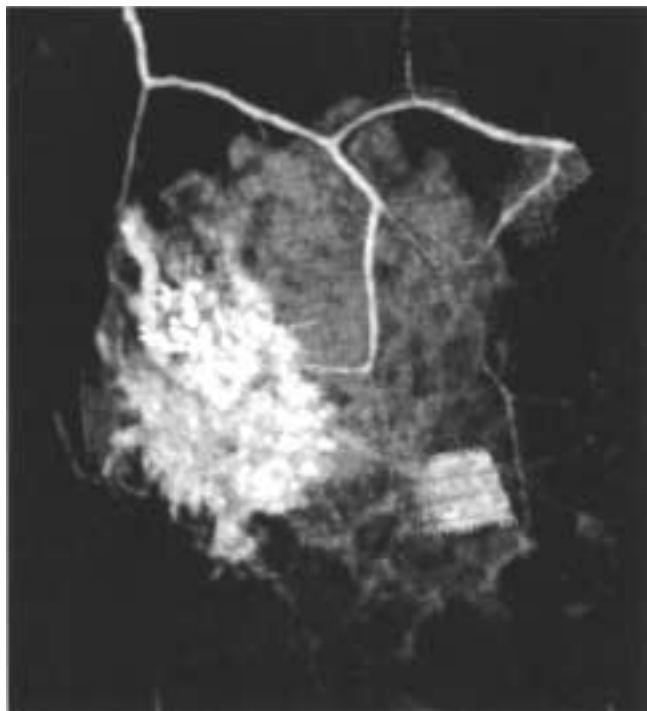
\*\*Overdiagnosis more than 2 cm in length, n=1

\*\*\*Positive surgical margins, n=2 (2/46 BCS)

<sup>a)</sup>Invasive ductal carcinoma with separate focus of fibroadenoma

<sup>b)</sup>Invasive ductal carcinoma with diffuse enhancement of mastopathy

seen in two DCIS and three invasive ductal carcinomas with IDS3 (Fig. 2). Separated lesion was seen in one case of invasive carcinoma and fibroadenoma (Fig. 3), and three multifocal/multicentric carcinomas. Multifocal tumors included two invasive ductal carcinomas. Two cases of multicentric tumors included two invasive ductal



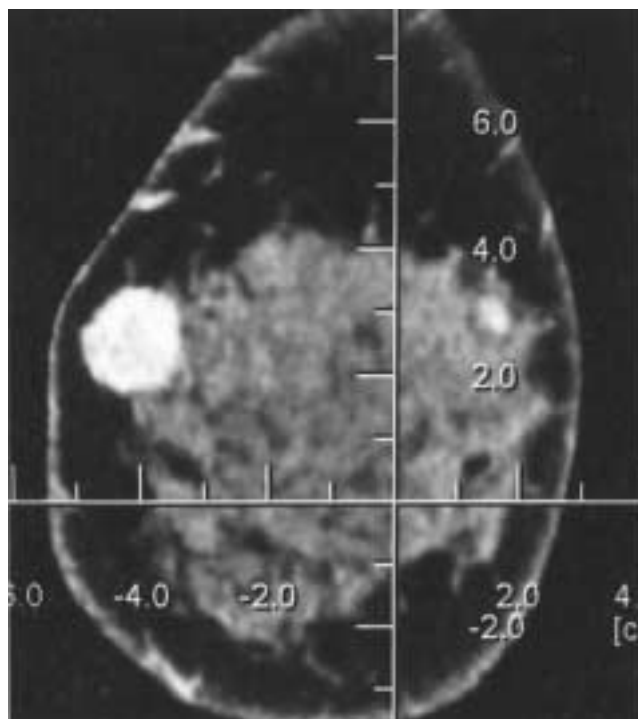
**Fig. 2.** A 35-year-old woman with invasive ductal carcinoma plus IDS3 (grouped lesion: crowded). MIP of MSCT shows a segmental enhancing lesion in the upper outer quadrant of the right breast.

carcinomas and three invasive ductal carcinomas (Fig. 4). There was no intraductal extension. Mixed lesion was seen in two multicentric carcinomas, one an invasive ductal carcinoma with IDS and separate foci of DCIS, and the other an invasive ductal carcinoma with minimal IDS and multiple separate foci of invasive tumors. Diffuse lesion was seen in one case each of DCIS, invasive ductal carcinoma without IDS, invasive ductal carcinoma with diffuse IDS, and multicentric carcinoma.

#### *MSCT and pathologic correlation*

The coincident rate of distribution pattern between MSCT and the histologic findings was 85.7% (60/70) (Table 3). There were four false-negative lesions in solitary and grouped patterns. One was a 2-mm DCIS, and the other cases were invasive carcinoma with IDS2 and IDS3, including two cases of positive surgical margin. False-positive lesions included two focal cancers with surrounding diffuse enhancement caused by fibrocystic disease, and one case of 5-mm-sized fibroadenoma. They showed the grouped pattern, separated pattern, and diffuse pattern. None of the false-negative lesions could be detected retrospectively by late-phase MPR images.

In invasive carcinoma, sensitivity and specificity for the detection of intraductal extension were 76% (19/25)



**Fig. 3.** A 55-year-old woman with invasive ductal carcinoma and fibroadenoma (separated lesion). Oblique coronal MPR image shows a markedly enhancing mass in the upper inner quadrant of the left breast. A small enhancing nodule is shown in the upper outer quadrant. Craniocaudal and transverse lines are drawn crossing over the nipple.

and 97% (32/33). The sensitivity and specificity for the detection of multifocal/multicentric lesions were, respectively, 85.7% (6/7) and 98% (50/51). Accuracy for the detection of tumor extent with a deviation of less than 2 cm in length was 94.9% (37/39) in solitary lesions, 87.5% (14/16) in the satellite grouped pattern, and 80% (4/5) in the crowded grouped pattern.

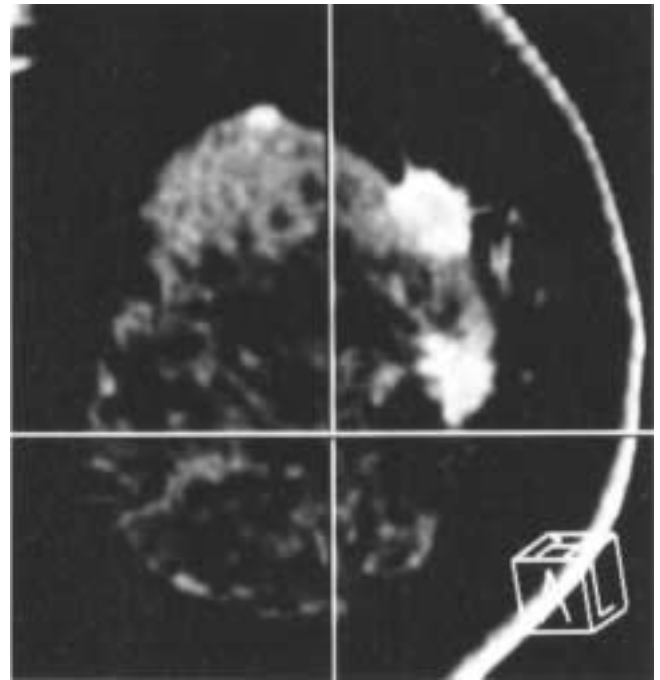
## DISCUSSION

Several studies have demonstrated that BCS is a highly acceptable alternative to mastectomy in selected women with early breast cancer.<sup>1,2</sup> BCS is an option in tumors smaller than 2-3 cm. At our institution, the cutoff value is generally 3 cm. However, some authors<sup>8</sup> claim that conservative therapy can be indicated in tumors as large as 5 cm and in multifocal/multicentric cancers in so far as all tumors can be totally removed. To avoid local recurrence caused by residual tumor, it is crucial to obtain precise information regarding the extent and distribution of the breast cancer before operation. Contrast-enhanced helical CT has been reported as an accurate imaging modality for the detection of local extension of breast cancer.<sup>4,7</sup> In addition, images obtained in the oblique

supine position, unlike magnetic resonance (MR) imaging, provide surgeons with better anatomical understanding and have been proved to be useful in surgical planning.<sup>6</sup>

The more recently developed MSCT is expected to be used for the analysis of detailed pathological changes such as intraductal extension and multifocal/multicentric foci of breast cancer. Because MSCT can achieve complete reconstruction of images in any direction retrospectively, precise deviation of tumor extent can be measured.<sup>9</sup> Breast cancer has variable tumor extension: satellite intraductal spread from the main tumor, extensive intraductal component, pure or predominant DCIS occupying a whole ductal tree, separate foci of invasive cancer, separate foci of DCIS, multiple foci in the whole breast, diffuse invasion replacing the whole breast, and several mixed patterns. Coronal MPR by MSCT is suitable for the evaluation of these variable tumor extensions.<sup>10</sup>

A new classification of tumor distribution pattern was used<sup>10</sup> in this study. Distribution pattern was well correlated with pathological extension (85.7%). Among solitary lesions detected by MSCT, a false-negative intraductal component was found in six cases (15.4%), and one of them had a surgical positive margin. One 2-mm-sized DCIS separated from the main invasive carcinoma could not be detected. However, there was no extensive intraductal component (IDS3). Precise tumor extent is important in solitary and grouped lesions because of their good indication for BCS. In this study, accuracy for the detection of tumor extent with a deviation of less than 2 cm in length was 94.9% (37/39) in solitary lesions, 87.5% (14/16) in the satellite grouped pattern, and 80% (4/5) in the crowded grouped pattern. The crowded grouped pattern included widespread pure or predominant DCIS. Indications of BCS in the crowded



**Fig. 4.** A 56-year-old woman with multicentric breast cancer (separated lesion). Oblique coronal MPR image shows three enhancing masses without additional enhancing foci in the left breast.

grouped pattern must be examined carefully.

Separated lesions included one case of invasive carcinoma and 5-mm-sized fibroadenoma in different quadrants. BCS and surgical biopsy were done in this case. CT attenuation of multiple enhancing lesions was not useful for differential diagnosis.<sup>11</sup> Fibroadenoma tended to show a more circumscribed mass, and the differential diagnosis between fibroadenoma and malignant lesions was relatively easy based on the morphology. However, small hypochoic nodules were

**Table 3. Correlation between MSCT pattern and histologic distribution**

MSCT pattern	Solitary	Grouped		Separated		Mixed	Diffuse
		Satellite	Crowded	Within quadrant	Between quadrants		
Solitary (n=39)	32	6***	0	0	1*	0	0
Grouped: satellite (n=16)	1**	15*	0	0	0	0	0
Grouped: crowded (n=5)	0	0	5***	0	0	0	0
Separated: within quadrant (n=1)	0	0	0	1	0	0	0
Separated: between quadrants (n=3)	1 <sup>a)</sup>	0	0	0	2	0	0
Mixed: between quadrants (n=2)	0	0	0	0	0	2	0
Diffuse (n=4)	1 <sup>b)</sup>	0	0	0	0	0	3

\*Underdiagnosis more than 2 cm in length, n=2

\*\*Overdiagnosis more than 2 cm in length, n=1

\*\*\*Positive surgical margins, n=2 (2/46 BCS)

<sup>a)</sup>Invasive ductal carcinoma with separate focus of fibroadenoma

<sup>b)</sup>Invasive ductal carcinoma with diffuse enhancement of mastopathy

not always easy to differentiate between benign and malignant lesions. When small enhancing lesions are detected by only MSCT, comparison with ultrasonography (US) is required. If the case is inconclusive, US-guided biopsy, surgical biopsy, or intraoperative pathologic assessment is useful.

There were two false-positive diffuse enhancements caused by mastopathy in the categories of grouped and diffuse lesions. In most mastopathy cases, diffuse enhancement was bilaterally symmetric.<sup>10</sup> These cases showed unilateral enhancement on MSCT, and negative findings on both mammography and US. In cases of unilateral diffuse enhancement, intraoperative assessment of the surgical margin is mandatory.

Breast MR imaging has high sensitivity for the detection, diagnosis, and staging of breast cancer.<sup>12</sup> The sensitivity of detecting intraductal spread on MR imaging is slightly higher than that on helical CT.<sup>6</sup> However, standardized guidelines for performing and interpreting breast MR imaging do not exist. The absence of consensus on diagnostic criteria for breast lesions is caused by the varied performances of MR units and different image acquisition protocols. On the other hand, MSCT has certain advantages: high spatial resolution, breast position suitable for the surgeon's anatomical approach, and evaluation of axillary and mediastinal lymph nodes and lung parenchyma. However, a real problem related to the use of CT in the diagnosis of breast disease is X-ray exposure. Therefore, the indications of performing MSCT in breast disease should be carefully evaluated, and further study using this classification of tumor distribution, in comparing these two modalities, is necessary.

In conclusion, MSCT is extremely accurate in the diagnosis of IDS and multicentricity of breast cancer. The distribution pattern determined by dynamic MSCT is thought to be useful in the preoperative assessment of indications of BCS.

#### ACKNOWLEDGMENT

The authors wish to thank Dr. Shu Ichihara, Department of Pathology, Nagoya National Hospital, for his comments on this article.

#### REFERENCES

- 1) Sarrazin D, Le MG, Arriagada R, *et al*. Ten-year results of a randomized trial comparing a conservative treatment to mastectomy in early breast cancer. *Radiother Oncol*, 14: 177–184, 1989.
- 2) Fisher B, Anderson S, Redmond CK, *et al*. Reanalysis and results after 12 years of follow-up in a randomized clinical trial comparing total mastectomy with lumpectomy with or without irradiation in the treatment of breast cancer. *N Engl J Med*, 333: 1456–1461, 1995.
- 3) Smitt MC, Nowels KW, Zdeblick MJ, *et al*. The importance of the lumpectomy surgical margin status in long-term results of breast conservation. *Cancer*, 76: 259–267, 1995.
- 4) Sardanelli F, Calabrese M, Zandrino F, *et al*. Dynamic helical CT of breast tumors. *J Comput Assist Tomogr*, 22: 398–407, 1998.
- 5) Akashi-Tanaka S, Fukutomi T, Miyakawa K, *et al*. Diagnostic value of contrast-enhanced computed tomography for diagnosing the intraductal component of breast cancer. *Breast Cancer Res Treat*, 49: 79–86, 1998.
- 6) Hiramatsu H, Enomoto K, Ikeda T, *et al*. Three-dimensional helical CT for treatment planning of breast cancer. *Radiat Med*, 17: 35–40, 1999.
- 7) Uematsu T, Sano M, Homma K, *et al*. Staging of palpable T1-2 invasive breast cancer with helical CT. *Breast Cancer*, 8: 125–130, 2001.
- 8) Harstell WF, Recine DC, Griem KL, *et al*. Should multicentric disease be an absolute contraindication to the use of breast-conserving therapy? *Int J Radiat Oncol Biol Phys*, 30: 49–54, 1994.
- 9) Tozaki M, Yamashita A, Kawakami M, *et al*. Diagnosis of breast cancer extent using dynamic multidetector-row CT: correlation between MPR imaging and pathological cross-sections. *Nippon Igaku Hoshasen Gakkai Zasshi*, 60: 560–567, 2000. (in Jpse.)
- 10) Tozaki M, Suzuki M, Kawakami M, *et al*. Classification of breast cancer extent by dynamic CT-mammography. *Jpn J Clin Radiol*, 47: 791–798, 2002.
- 11) Uematsu T, Sano M, Homma K. False-positive helical CT findings of multifocal and multicentric breast cancer: is attenuation of tumor useful for diagnosing enhanced lesions? *Breast Cancer*, 9: 62–68, 2002.
- 12) Orel SG, Schnall MD. MR imaging of the breast for the detection, diagnosis, and staging of breast cancer. *Radiology*, 220: 13–30, 2001.