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Improving Interpretative Performance: Test Sets as a Learning Tool for Radiologists, Testing and/or Building Test Sets – Characteristics、Use, and Impact

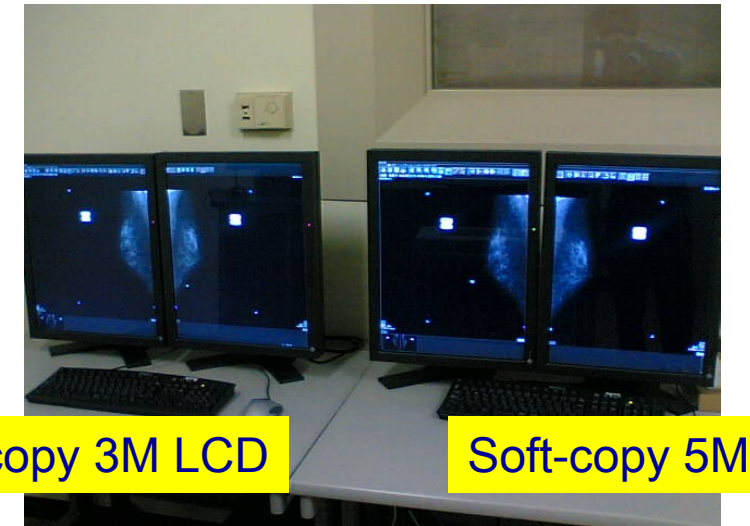
Observer Performance in Detection of Breast Cancer Among Hard-Copy Film and Soft-Copy Readings in 3MP, 5MP-LCD Monitors

Noriaki Ohuchi, MD, PhD
Professor of Surgical Oncology
Tohoku University, Sendai, Japan

Purpose

- The diagnostic performance of digital mammography (DM) has been recognized, as the DMIST showed that DM using a flat panel detector and computed radiography (CR) system was superior for detecting breast cancer in women aged under 50.
- While the CR mammograms in the DMIST are interpreted mainly for hard-copy films, soft-copy reading of CR mammograms is not in routine use in screening.
- Only a few studies compared the diagnostic performance of CR using hard-copy and soft-copy reading, although with the sampling pitch at 100 μm.
- The sampling pitch of CR for mammography has improved from 100 to 50 μm.
- **In this study we compared the diagnostic performances in the detection of breast cancer on hard-copy film, 3-megapixel (3MP) liquid-crystal-display (LCD) monitor and 5MP LCD monitor.**

Hard-copy films



Soft-copy 3M LCD

Soft-copy 5M LCD

Material

- 200 digital mammograms with 100 subjects
  - 68 normal controls who underwent screening mammography in 2004 and 2005
  - 32 patients with surgically proven breast cancer in Tohoku University Hospital during the same period
- Besides, 33 cases were prepared for training before assessing the 100 cases.

Table 1. The distribution of breast composition of control and breast cancer

Breast composition	Control	Breast cancer
Extremely dense	6	0
Heterogeneously dense	28	20
Scattered fibroglandular	28	8
Entirely fatty	6	4
Total	68	32

Digital technology

- Equipment：Mammomat 3000Nova (Siemens Medical Systems, Germany)
- Digitizing reader：Computed Radiography System, FCR 5000MA plus, sampling pitch 50μm (Fujifilm Medical , Japan)
- Printer：Laser film imager, Dry Pix 7000 (Fujifilm Medical , Japan)

Soft-copy display

- 3MP monochrome LCD (20.8inch)×2; EIZO RadiForce FC-2090 (NANAO, Japan)
  - clear base, glare panel
  - brightness 450cd/cm^2, contrast ratio 600:1,
  - 8-bit grayscale, adjusted to DICOM Part 14 GSDF
- 5MP monochrome LCD (21.3inch)×2 ; EIZO RadiForce G51G (NANAO, Japan)
  - clear base, glare panel
  - brightness 450cd/cm^2, contrast ratio 800:1
  - 10-bit grayscale, adjusted to DICOM Part 14 GSDF

Image interpretation

- 12 doctors independently assessed mammograms presented in a random order. (Time: no limitation)
  - Interval between each reading is more than 4 weeks.
- Information before reading
  - 100 subjects including about 30 patients with breast cancer
- Ambient lighting: at around 20 lux
- Soft-copy reading： free to magnify the images and to change the contrast
- Findings：tumor, calcification, others and location
- Probability of malignancy：

1. 7-point scale
   1．Definitely not malignant
   2．Almost certainly not malignant
   3．Probably not malignant
   4．Possibly malignant
   5．Probably malignant
   6．Almost certainly malignant
   7．Definitely malignant
2. Continuous probability：0～100%

Viewing software

- Prototype software（Fujifilm Medical, Japan）
  - OS: MS Windows2000

Statistical analysis

- Calculation of areas under the ROC curve (AUCs) for 3MP-LCD, 5MP-LCD, and Hard-copy by the software using Jackknife method：LABMRMC ver1.4b
- AUCs with each reading modality were compared on both malignancy scales. Bonferroni correction was used for multiple comparisons, with a P value of 0.017 or less considered to indicate statistical significance.
- Creation of ROC curve: PlotROC (Metz CE, Univ. of Chicago)

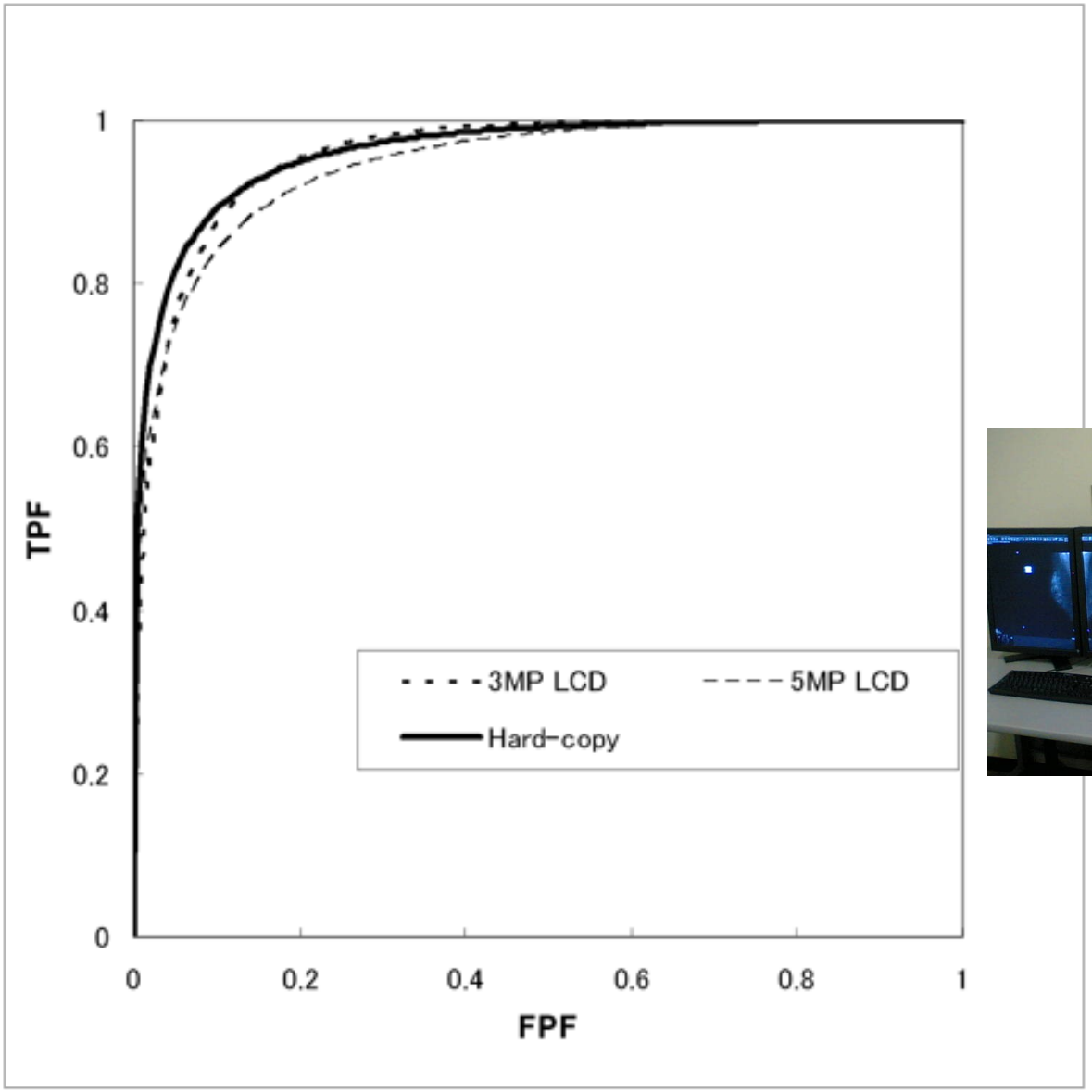
Result (1): AUCs of **all readers**
3MP-LCD vs. 5MP-LCD vs. Hard-copy

	3MP-LCD	5MP-LCD	Hard-copy
7-point scale	0.954± 0.016 *	0.947± 0.021**	0.956± 0.018***
Continuous (0 ~ 100%)	0.943± 0.016[a]	0.923± 0.021[b]	0.944± 0.018[c]

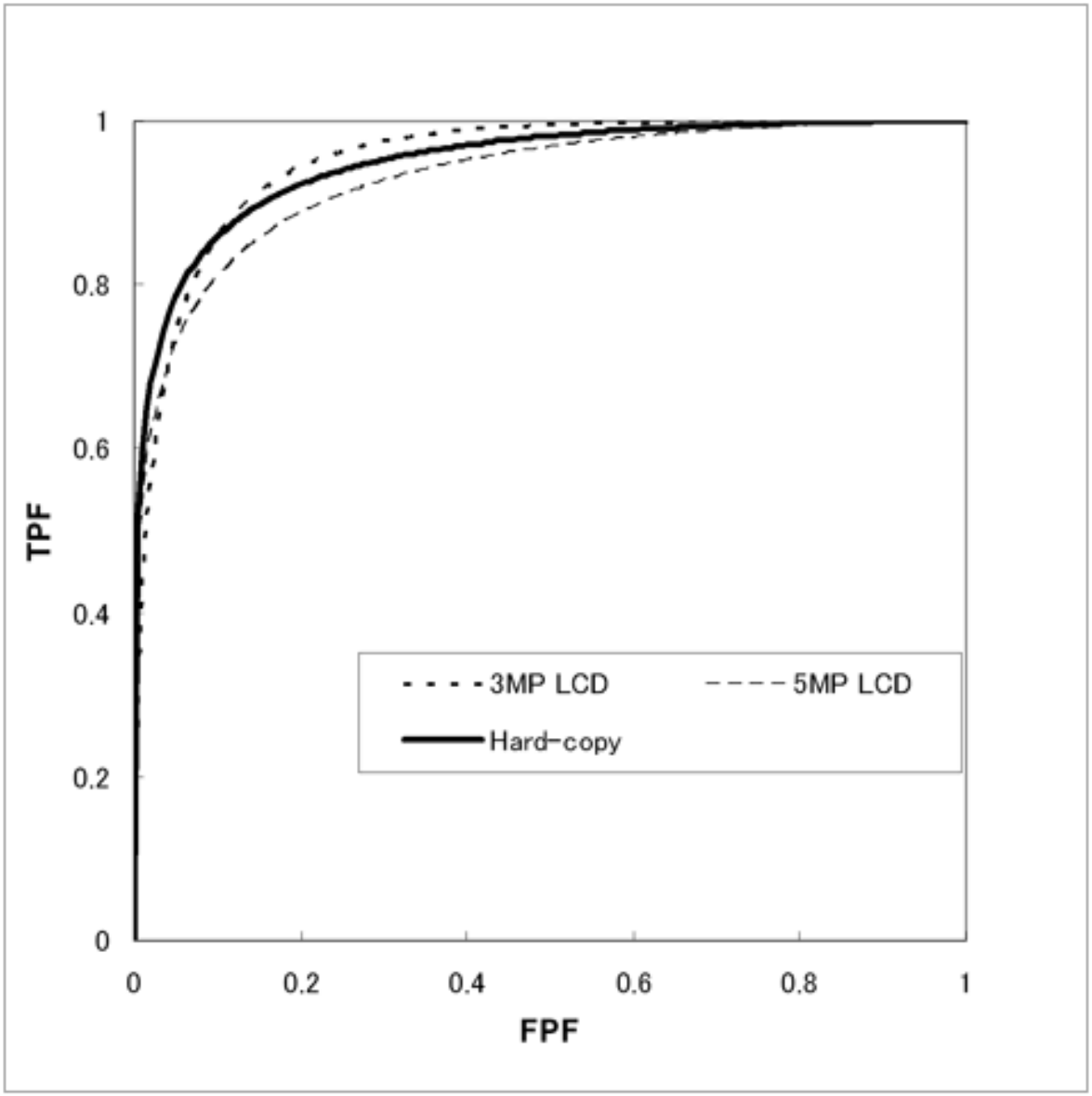
Paired-t test with Bonferroni correction: * ~ ***, a ~ c: n.s.

(Yamada T, Ohuchi N, et al. Eur Radiol *in press)*

ROC curve on **a 7-point scale**
3MP-LCD vs. 5MP-LCD vs. Hard-copy



ROC curve on **a continuous point scale**
3MP-LCD vs. 5MP-LCD vs. Hard-copy



Result (2): AUCs for **mass** or others
3MP-LCD vs. 5MP-LCD vs. Hard-copy

	3MP-LCD	5MP-LCD	Hard-copy
7-point scale	0.936± 0.027*	0.925± 0.033**	0.949± 0.026***
Continuous (0 ~ 100%)	0.925± 0.027[a]	0.905± 0.034[b]	0.932± 0.030[c]

Paired-t test with Bonferroni correction: * ~ ***, a ~ c: n.s.

Result (3): AUCs for **microcalcifications** 3M-LCD vs. 5M-LCD vs. Hard-copy

	3MP-LCD	5MP-LCD	Hard-copy
7-point scale	0.980± 0.011*	0.974± 0.009**	0.969± 0.021***
Continuous (0 ~ 100%)	0.975± 0.011[a]	0.957± 0.019[b]	0.963± 0.026[c]

Paired-t test with Bonferroni correction: * ~ ***, a ~ c: n.s.

(Yamada T, Ohuchi N, et al. Eur Radiol *in press)*

Discussion

ACRIN DMIST study by Pisano et al.

1)Pisano ED, Gatsonis C, Hendrick E et al. Diagnostic performance of digital versus film mammography for breast cancer screening. N Engl J Med. 2005;353:1773-1783

2)Pisano ED, Hendrick E, Yaffe MJ, Baum JK et al. Diagnostic accuracy of digital versus film mammography: exploratory analysis of selected population subgroups in DMIST. Radiology 2008; 246:376-383

3)Hendrick E, Cole FB, Pisano ED, Acharyya S et al: Accuracy of soft-copy digital mammography versus that of screen-film mammography according to digital manufacturer: ACRIN DMIST retrospective multireader study. Radiology 2008;247:38-48

Oslo studies by Skaane et al

4)Skaane P, Young K, Skjennald A. Population-based mammography screening: comparison of screen-film and full-field digital mammography with soft-copy reading-Oslo Istudy. Radiology 2003;229:877-884

5)Skaane P, Skjennald A: Screen-film mammography versus full-field mammography with soft-copy reading: randomized trial in a population-based screening program-the Oslo II study. Radiology 2004;232:197-204

6)Skaane P, Hofvind S, Skjennald A. Randomized trial of screen-film versus full-field digital mammography with soft-copy reading in population-based screening program: follow-up and final results of Oslo II study. Radiology 2007;244:708-717

Double Reading vs Single +CAD

7)Gilbert FJ, Astley SM, McGee MA et al: Single reading with CAD and double reading of screening mammograms in the UK Breast Screening Program. Radiology 2006;241:47-53

8)Gromet M: Comparison of CAD to double reading of screening mammograms: Review of 231,221 mammograms. AJR 2008;190: 354-359

Discussion

As these studies focused on the ability of DM to detect BC, a full evaluation of soft-copy reading may not been achieved.
For instance, the Oslo I and II studies both compared screen-film MG and FFDM, although soft-copy reading was not specifically evaluated.

We took full advantage of the benefits of the existing CR system and soft-copy-reading, i.e., the $50\mu m$ spatial resolution, and free adjustment of the windows and contrast.

Furthermore, we took care in selecting the subjects to fit for breast cancer screening. Indeed, 53% of cancers were detected in screening with small size of mass.

Skaane has discussed the importance of the reading environment for soft-copy reading. Our study provided an appropriate environment with quiet reading places and the amibient light set at 20 lux, as the glare panel used in our study reflected the objects.

Conclusion

- Soft-copy readings in 3MP- and 5MP-LCD monitors were comparable to the reading on hard-copy film in detection of breast cancer.

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Summary of RCTs of Breast Cancer Screening

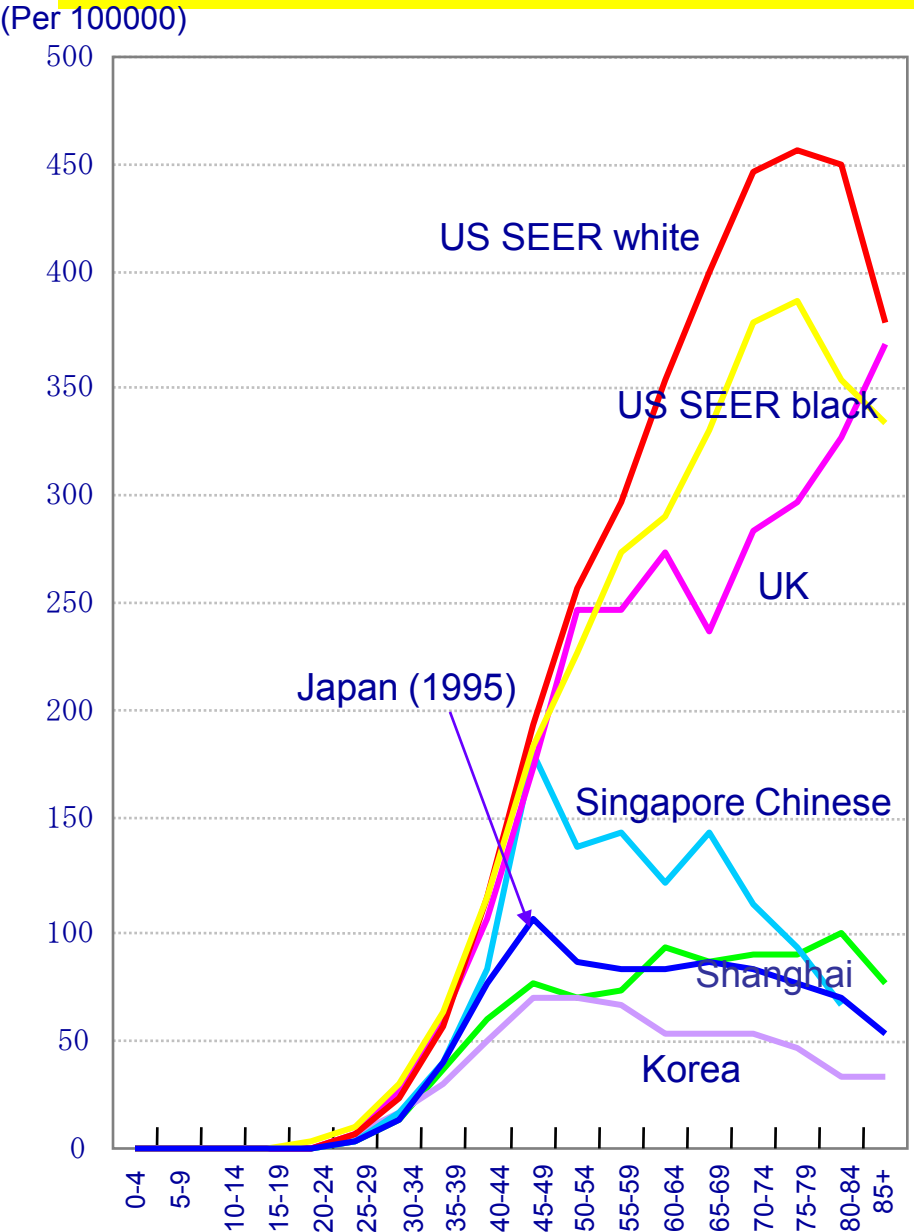
Study (duration)	Screening Protocol	Frequency	Age	Invited	Control	Years of follow-up	Relative risk (95% CI)
HIP (1963-69)	2V MM CBE	12M 4 rounds	40-49 50-64	14,432 16,568	14,701 16,299	18 18	0.77 (0.53-1.11) 0.80 (0.59-1.08)
Edinburgh (1979-88)	1 or 2V MM CBE (initial)	24M 4 rounds	45-49 50-64	11,755 11,245	10,641 12,359	12.6 10	0.81 (0.54-1.20) 0.85 (0.62-1.15)
Kopparberg (1977-85)	1V MM	24M 4 rounds	40-49 50-74	9,650 28,939	5,009 13,551	15.2 11	0.67 (0.37-1.22) 0.58 (0.43-0.78)
Ostergotland (1977-85)	1V MM	24M 4 rounds	40-49 50-74	10,240 28,229	10,411 26,830	14.2 11	1.02 (0.59-1.77) 0.73 (0.56-0.97)
Malmo (1976-90)	1 or 2V MM	18-24M 5 rounds	45-49 50-69	13,528 17,134	12,242 17,165	12.7 9	0.64 (0.45-0.89) 0.86 (0.64-1.16)
Stockholm (1981-85)	1V MM	28M 2 rounds	40-49 50-64	14,185 25,815	7,985 12,015	11.4 7	1.01 (0.51-2.02) 0.65 (0.40-1.08)
Gothenburg (1982-88)	2V MM	18M 5 rounds	39-49 50-59	11,724 9,276	14,217 16,394	12 5	0.56 (0.32-0.98) 0.91 (0.62-1.52)
CNBSS-1, 2 (1980-87)	2V MM CBE	12M 4-5 rounds	40-49 50-59	25,214 19,711	25,216 19,694	10.5 7	1.14 (0.83-1.56) 0.97 (0.62-1.52)

Mammography is the only modality proven to reduce mortality from breast cancer

- Limitation in women aged $\leq$ 49
- These RCTs were designed more than 30 years ago.

Is mammography effective enough for women aged 40-49?

Breast cancer incidence according to age



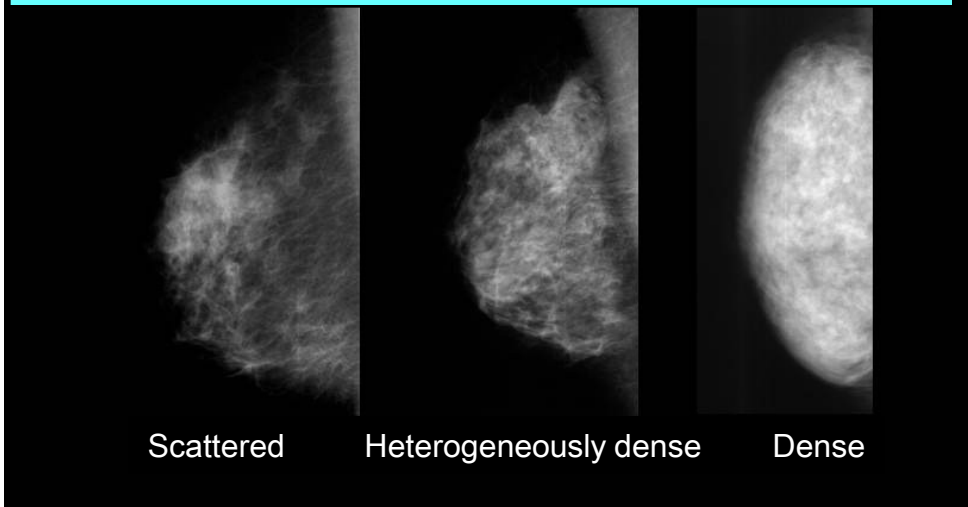
Breast density and sensitivity

Rate of mammograms based on breast density (High and heterogeneously dense)

- 40-49 69%
- 50-59 26%
- 60-69 12%

Sensitivity of mammography screening based on Miyagi cancer registry

- 40-49 71%
- 50-59 85%
- 60-69 87%



Japan Strategic Anti-cancer Randomized Trial (J-START)

RCT on effectiveness of ultrasonography (US) for breast cancer screening

- 2007～2011
- Budget: $10Milion

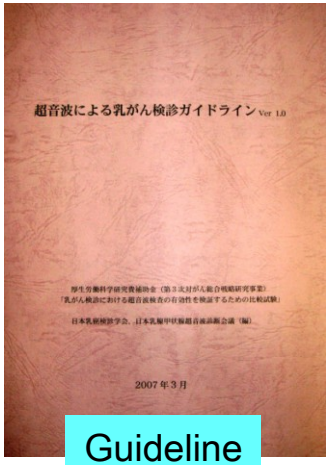
Background
1. Breast cancer mortality is increasing in Japan
2. Highest incidence in 40s, with higher breast density
3. US is clinically available, but not for screening use
4. No evidence of mortality reduction by US screening

Standardization of US technique and interpretation in screening

Targets: 100,000 women aged 40-49、50,000 of each
Method: ＲＣＴ
- Mammography + US *versus* Mammography

Outcomes until 2011
- Primary Endpoint: Sensitivity, Specificity, Detection rate
- Secondary Endpoint: Incidence rate of advanced BC

Final outcome: Mortality reduction



Guideline


Breast Phantom


Hands on training

Two days education course


Qualifying test

Promotion of large-scaled RCT according to the National Cancer Act (effective