

7-1-2009

## Comparison of BI-RADS categories and recommendations from mammography alone and mammography with subsequent breast ultrasound in women with BI-RADS 1 and 2 screening mammogram

B. Tiraratchailert

Follow this and additional works at: <https://digital.car.chula.ac.th/clmjournal>



Part of the [Medicine and Health Sciences Commons](#)

---

### Recommended Citation

Tiraratchailert, B. (2009) "Comparison of BI-RADS categories and recommendations from mammography alone and mammography with subsequent breast ultrasound in women with BI-RADS 1 and 2 screening mammogram," *Chulalongkorn Medical Journal*: Vol. 53: Iss. 4, Article 6.

DOI: <https://doi.org/10.58837/CHULA.CMJ.53.4.5>

Available at: <https://digital.car.chula.ac.th/clmjournal/vol53/iss4/6>

This Article is brought to you for free and open access by the Chulalongkorn Journal Online (CUJO) at Chula Digital Collections. It has been accepted for inclusion in Chulalongkorn Medical Journal by an authorized editor of Chula Digital Collections. For more information, please contact [ChulaDC@car.chula.ac.th](mailto:ChulaDC@car.chula.ac.th).

## Comparison of BI-RADS categories and recommendations from mammography alone and mammography with subsequent breast ultrasound in women with BI-RADS 1 and 2 screening mammogram

Benyaporn Tiraratchailert\*

**Tiraratchailert B. Comparison of BI-RADS categories and recommendations from mammography alone and mammography with subsequent breast ultrasound in women with BI-RADS 1 and 2 screening mammogram. Chula Med J 2009 Jul – Aug; 53(4): 293 - 307**

- Objective** : To evaluate false negative rate of mammography according to BI-RADS categories and recommendations before breast ultrasound (US) in women with BI-RADS 1 and 2 screening mammography and to study the effects of breast composition, age and availability of prior mammography on changing of recommendation after breast US.
- Setting** : Bangkok Metropolitan Administration General Hospital
- Research design** : A retrospective cohort study.
- Patients** : Women who received screening mammography with mammographic BI-RADS 1 and 2, and subsequent breast US were performed in the same day from July 2005 to February 2007.
- Methods** : Mammograms of 1003 women were reviewed. Mammographic findings were recorded and mammographic BI-RADS category ( $BI-RADS_M$ ) and recommendation ( $RECOM_M$ ) were assigned. Breast US reports and images were reviewed. US findings, final BI-RADS

\* Bangkok Metropolitan Administration General Hospital, PomPrapSattruPhai, Samphanthawong, Bangkok 10510, Thailand

category ( $BI-RADS_F$ ) and final recommendation ( $RECOM_F$ ) were recorded. False negative rate of  $BI-RADS_M$  and  $RECOM_M$  were analyzed using  $BI-RADS_F$  and  $RECOM_F$  as the gold standards. The effects of age, breast composition and availability of previous mammogram on incorrect recommendation were evaluated.

**Results** : False negative rate of  $BI-RADS_M$  categories was 7.68% (95% CI = 6.14 - 9.56) and of  $RECOM_M$  was 2.59% (95%CI = 1.73 - 3.83). The effects of breast composition and availability of prior mammogram for comparison on recommendation change after breast US were statistically significant. Women with dense breasts were 10.64 times (95%CI = 1.43 - 79.13) more likely to have recommendation change than women with non-dense breasts. Women without prior mammogram were 11.44 times (95%CI = 2.68 - 48.78) more likely to have recommendation change than women with prior films. Age had no significant effect on recommendation change after breast US.

**Conclusion** : A small proportion (2.59%) of women with mammographic BI-RADS 1 and 2 in screening mammography had recommendation change following breast US, particularly women with non-dense breasts and women with prior mammography available for comparison. This suggests lack of necessity to perform breast US in women with negative or benign findings on screening mammography of non-dense breast group and also in the group with available interval mammographic images.

**Keywords** : BI-RADS Categories, Recommendations, Breast Ultrasound, BI-RADS 1, BI-RADS 2, Screening Mammogram.

Reprint request: Tiraratchailert B. Bangkok Metropolitan Administration General Hospital,  
PomPrapSattruPhai, Samphanthawong, Bangkok 10510, Thailand.

Received for publication. May 12, 2009.



- ผลการวิจัย** : ผลลบลงของ  $BI-RADS_M$  เป็น 7.68% (95%CI = 6.14-9.56) และของ  $RECOM_M$  เป็นเพียง 2.59% (95%CI = 1.73-3.83) ความหนาแน่นของเนื้อเต้านม และการมีฟิล์มแมมโมแกรมเก่าสำหรับเปรียบเทียบมีผลต่อการเปลี่ยนแปลงคำแนะนำหลังการตรวจอัลตราซาวด์เต้านม อย่างมีนัยสำคัญทางสถิติ ผู้ที่มีความหนาแน่นของเนื้อเต้านมมากมีความเสี่ยงที่จะมีการเปลี่ยนแปลงคำแนะนำสูงกว่าผู้ที่มีความหนาแน่นของเนื้อเต้านมน้อย 10.64 เท่า (95%CI = 1.43 - 79.13) ผู้ที่ไม่มีฟิล์มแมมโมแกรมเก่าสำหรับเปรียบเทียบมีความเสี่ยงที่จะมีการเปลี่ยนแปลงคำแนะนำสูงกว่าผู้ที่มีฟิล์มแมมโมแกรมเก่า 11.44 เท่า (95%CI = 2.68 - 48.78) อายุไม่มีผลต่อการเปลี่ยนแปลงคำแนะนำหลังการตรวจอัลตราซาวด์ อย่างมีนัยสำคัญทางสถิติ
- วิจารณ์และสรุป** : ผู้ที่ผลแมมโมแกรมอย่างเดียวเป็น  $BI-RADS$  1 และ 2 ในการตรวจคัดกรองมะเร็งเต้านมเพียงส่วนน้อย (2.59%) ที่มีการเปลี่ยนแปลงคำแนะนำการตรวจรักษาหลังจากการตรวจอัลตราซาวด์เพิ่มเติม โดยเฉพาะอย่างยิ่งในผู้ที่มีความหนาแน่นของเนื้อเต้านมน้อย และผู้ที่มีฟิล์มแมมโมแกรมเก่าสำหรับเปรียบเทียบ ดังนั้นจึงไม่จำเป็นต้องตรวจอัลตราซาวด์เต้านมเพิ่มเติมในผู้ที่ผลแมมโมแกรมเพื่อตรวจคัดกรองมะเร็งเต้านมเป็น  $BI-RADS$  1 หรือ 2 ในกรณีที่มีความหนาแน่นของเนื้อเต้านมน้อย และในกรณีที่มีฟิล์มเก่าเปรียบเทียบ
- คำสำคัญ** :  $BI-RADS$  categories, คำแนะนำการตรวจรักษา, อัลตราซาวด์เต้านม,  $BI-RADS$  1,  $BI-RADS$  2, การตรวจคัดกรองมะเร็งเต้านม.

Mammography is the most accurate method for breast cancer screening and can reduce mortality rate from breast cancer.<sup>(1,2)</sup> According to American College of Radiology’s breast imaging reporting and data system (ACR BI-RADS), an overall impression of mammography report comprises of BI-RADS assessment category and recommendation that is appropriate for each category.<sup>(3)</sup> Both BI-RADS category 1 and category 2, which indicate that there is no mammographic evidence of malignancy, have same recommendation - routine screening mammogram, while other BI-RADS categories have different recommendations.

Interpretation of screening mammography can be performed in two ways: (a) immediate interpretation, which images are evaluated and results are communicated with the patient at the time of the initial visit and additional examination can be performed in the same visit, and (b) batch interpretation, which images are evaluated after the patient has left the hospital and the suspicious cases or the cases need further examinations are recalled for additional imaging on a different day. Batch interpretation shows higher efficacy and higher specificity than immediate interpretation, without significant difference in cancer detection rate and it is one measure to improve the economic efficiency of screening mammography.<sup>(4,6)</sup> Nowadays 93% of hospitals in the United States use batch interpretation.<sup>(7)</sup> Almost all hospitals in Thailand including the BMA General Hospital still use immediate interpretation in screening mammography service, and additional breast ultrasonography (US) is performed in most cases including women who have negative or benign findings on mammographic

films. This type of practice results in limitation of number of women appointed per day because the radiologists have to spend more time per case performing breast US. Abnormalities detected by additional breast US may affect final BI-RADS category and recommendation. However, the negative and benign US findings do not alter the recommendation. If additional breast US causes no significant change in final recommendation in women with negative or benign findings on screening mammographic films, performing breast US may not be necessary in this group of women; batch interpretation should be used instead of immediate interpretation for screening mammography service to serve growing demand for breast cancer screening.

This study had as its objectives to evaluate false negative rate of BI-RADS categories and recommendations of screening mammography before breast US compared with those after breast US, in women with negative and benign findings on screening mammography, and to study the influence of breast composition, age and availability of prior mammography on changing of recommendation after breast US.

## Materials and Method

This study has been approved by the Ethics Committee for Researches Involving Human Subjects of the Bangkok Metropolitan Administration.

### Study location:

The BMA General Hospital is a 400-bed hospital with 5 full-time radiologists. All radiologists have experience in mammography for 6 - 17 years.

## Mammographic screening practice in the BMA

### General hospital includes:

Routine practice of screening mammography is performed by acquiring two standard views (mediolateral oblique and craniocaudal views) of each breast. Mammograms are obtained using mammographic unit (Senix SF 600T; General Electric Medical Systems, Milwaukee, WI), cassettes (Min-R 2000; Kodak, Rochester, NY), films (Min-R 2000; Kodak, Rochester, NY) and processing (Kodak miniloader 2000P; Kodak, Rochester, NY).

After immediate evaluation of mammograms by an attending radiologist, additional mammographic views may be requested whether an abnormality is suspicious. Then, whole breast US is performed by the same radiologist, using a high-resolution US unit (Acuson 128XP/10C; Acuson, Mountain View CA.) with a high-frequency (7.5 - MHz) linear-array transducer. Hard-copy US image of any positive finding is printed on thermal print paper and the radiologist makes decision on final BI-RADS categories and final recommendation.

### Study design:

A retrospective cohort study was conducted from June to December 2008. List of all patients (2,102 patients) who received mammography at the hospital from July 2005 to February 2007 was complied. Clinical data, written in request forms by referring physicians and recorded in patient information forms by mammographic technologists, were retrospectively reviewed to identify patients who had no breast symptom and received mammography on screening purpose. One thousand, two hundred and ninety six asymptomatic patients

(1,296) were identified and included into this study. For each patient, the original mammograms were reviewed by the principle researcher (B.T.). If previous mammograms were available, comparison of current with previous films would be done. The findings were recorded and the researcher assigned mammographic BI-RADS category ( $BI-RADS_M$ ) according to the ACR BI-RADS manual, as well as mammogram recommendation ( $RECOM_M$ ). Then, the breast US report and hard-copy image (available only for women with positive finding) were reviewed. The US findings, the original final BI-RADS category ( $BI-RADS_F$ ) and the final recommendation ( $RECOM_F$ ) which was assigned by attending radiologists were recorded.

Women's age, total number of mammography and intervals between each consecutive mammography were recorded. Breast composition was estimated. Breast compositions were grouped according to ACR BI-RADS guideline<sup>(3)</sup> and later into two large groups: (a) dense breasts, which included homogeneously and heterogeneously dense breasts, and (b) non-dense breasts, which included scattered dense and almost entirely fatty breasts.

### Exclusion criteria:

Persons with the following conditions were excluded: mammogram not available ( $n = 123$ ), radiologist requested additional mammographic views ( $n = 37$ ),  $BI-RADS_M$  categories 3, 4 or 5 ( $n = 80$ ), previous unilateral mastectomy ( $n = 17$ ), previous breast implant ( $n = 1$ ) and no subsequent breast US due to almost entirely fatty breasts ( $n = 35$ ).

Statistical analysis:

BI-RADS<sub>F</sub> and RECOM<sub>F</sub> were used as gold standards.

The false negative rates of BI-RADS<sub>M</sub> was defined as:

Number of patients whose  
BI-RADS<sub>F</sub> changed from BI-RADS<sub>M</sub> x100

Number of all patients

The false negative rates of RECOM<sub>M</sub> was defined as:

Number of patients whose  
RECOM<sub>F</sub> changed from RECOM<sub>M</sub> x100

Number of all patients

The effects of age, breast composition and availability of previous mammogram on incorrect recommendation were evaluated. The statistics used for bivariate analysis were relative risk (RR) and 95% confidence interval (95%CI), t-test for different between two means and chi-square test for different between two proportions. The statistics used for multiple logistic regression were odd ratio (OR) and its 95%CI. Data were analyzed by Epiinfo 6 and Stata 6 software.

Result

Of 1,003 patients recruited in the study, the

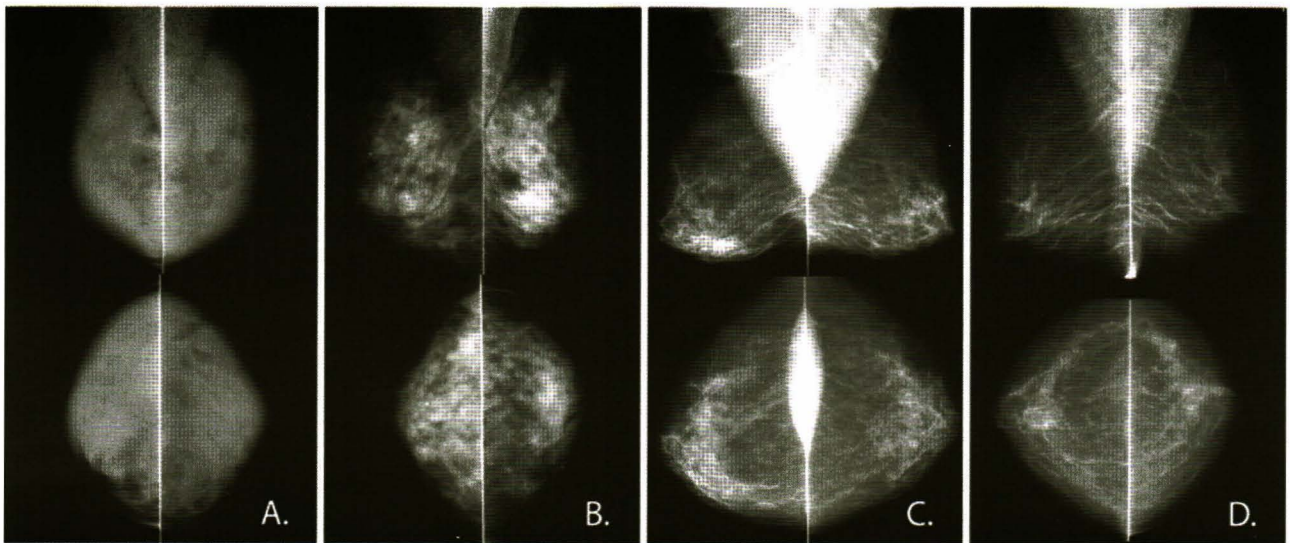
age range was between 28 - 82 years with the mean of 52.9 years. More than half had heterogeneously dense breast. Four hundreds and seventy patients (470, 46.86%) had previous mammograms from 1 to 8 times (median 2 times). Time between the first and current mammogram was from 5 to 106 months (median 27 months). Five hundred and eighteen patients (518, 51.65%) had negative mammograms (BI-RADS<sub>M</sub> category1), while 485 (48.35%) had benign findings (BI-RADS<sub>M</sub> category 2). Detailed characteristics of the findings are in table 1. There were two positive findings in 5 patients.

Breast US findings showed 855 negative findings, 116 benign and 32 probably benign findings. BI-RADS<sub>F</sub> was category 1 in 855 patients (85.25%), category 2 in 122 patients (12.16%) and category 3 in 26 patients (2.59%) (Fig. 1 - 4). There were no BI-RADS<sub>F</sub> categories 4 and 5 in this review. Comparison of BI-RADS<sub>M</sub> and BI-RADS<sub>F</sub> categories is shown in table 2. They were unchanged in 926 patients (92.32%) and changed in 77 patients (7.68%). Of the 77 patients with BI-RADS categories changed, recommendations remained unchanged (RECOM<sub>M</sub> similar to RECOM<sub>F</sub>) in 51 patients who had BI-RADS<sub>M</sub> category 1 and BI-RADS<sub>F</sub> category 2.

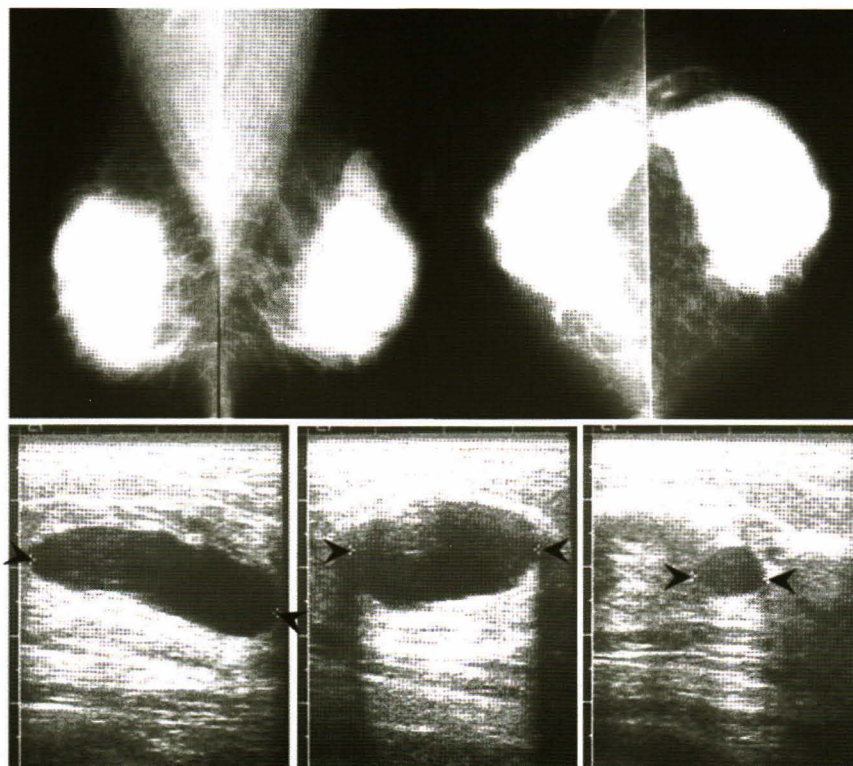
Table 1. Characteristics of the 490 positive benign mammographic findings in 485 patients.

Findings	Number	%
Round mass	5	1.02
Benign-appearing calcifications	459	93.67
Architectural distortion, stable	1	0.20
Intramammary lymph node	6	1.22
Global asymmetry	5	1.02
Focal asymmetry, stable	13	2.65
Skin thickening, postsurgical	1	0.20

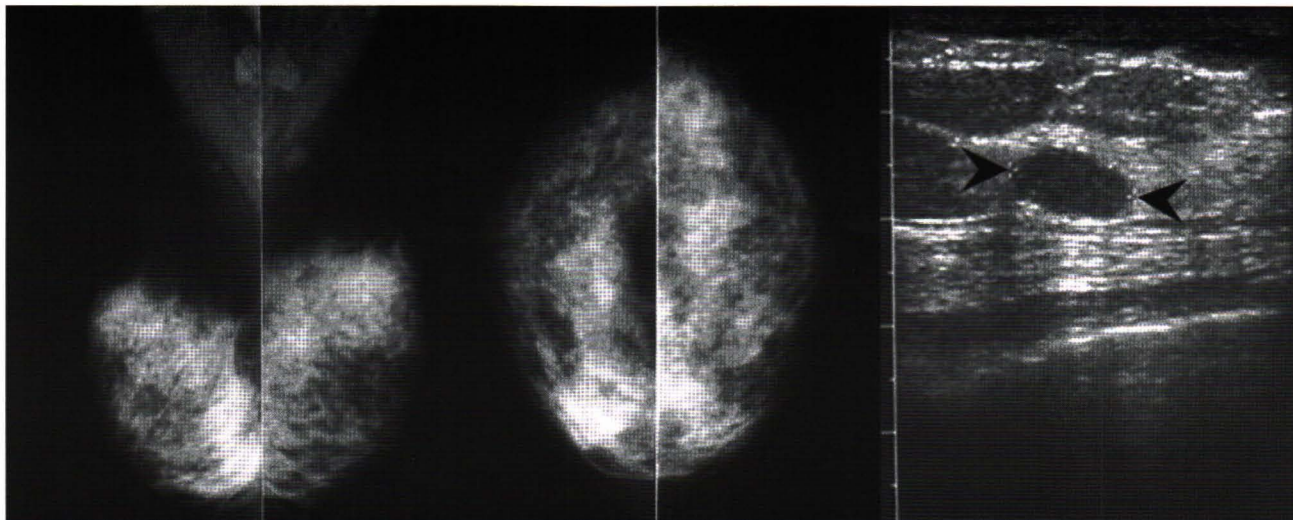
Note: There were five patients who had two positive findings.



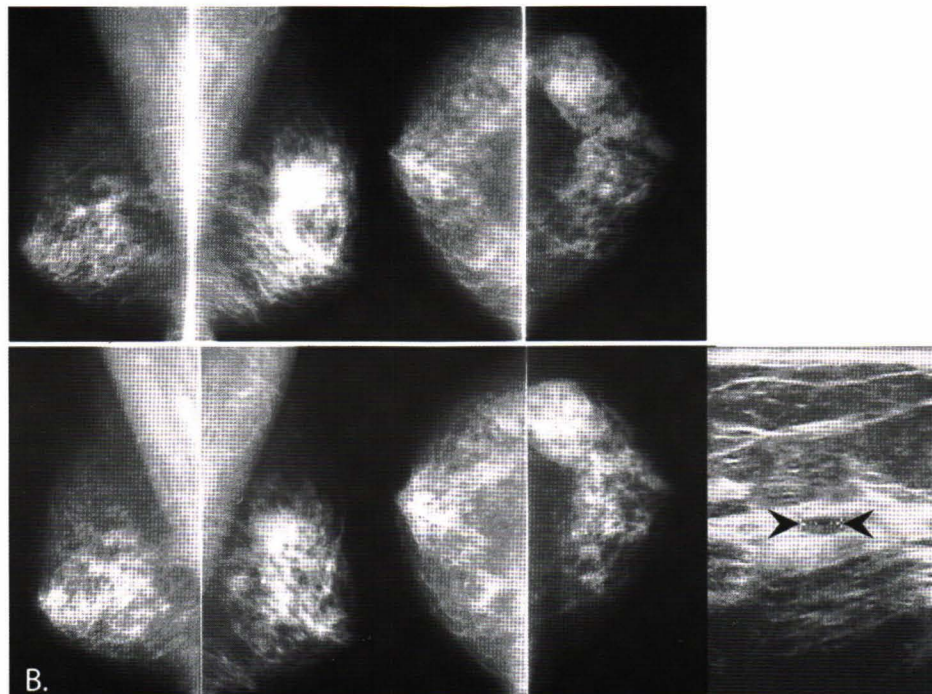
**Figure 1.** Examples of women with various breast compositions with mammographic BI-RADS 1 or 2: (A.) homogeneously dense breast, (B.) heterogeneously dense breasts, (C.) scattered dense breasts and (D.) almost entirely fatty breast. Breast US of all cases showed no abnormality.



**Figure 2.** A 51-year-old woman with homogeneously dense breasts and bilateral scattered eggshell calcifications, benign mammographic findings. US showed three cysts (◀) in both breasts, 1.1-3.7cm in sizes, also benign findings. Recommendation was unchanged - routine screening mammography.



**Figure 3.** A 44-year-old woman with homogeneously dense breasts and negative mammogram. US showed a 1.2cm oval hypoechoic mass (◀) in LUIQ. After breast US, recommendation was changed from routine screening mammography to initial short-interval follow-up.



**Figure 4.** A 50-year-old woman with heterogeneously dense breasts and bilateral coarse and eggshell calcifications. Current films (B) unchanged from prior films from 26 months ago (A). US showed a new 0.4cm oval hypoechoic mass (◀) in LUIQ. After breast US, recommendation was changed from routine screening mammography to initial short-interval follow-up. This is one of two cases with prior mammography available for comparison whose recommendation changed after breast US.

**Table 2.** Comparison of mammographic BI-RADS categories with final BI-RADS categories after subsequent breast US.

BI-RADS <sub>M</sub>	BI-RADS <sub>F</sub>					Total
	BI-RADS <sub>F</sub> 1	BI-RADS <sub>F</sub> 2	BI-RADS <sub>F</sub> 3	BI-RADS <sub>F</sub> 4	BI-RADS <sub>F</sub> 5	
BI-RADS <sub>M</sub> category 1	456	51	11	0	0	518
BI-RADS <sub>M</sub> category 2	0	470	15	0	0	485
Total	456	521	26	0	0	1003

BI-RADS<sub>M</sub> is mammographic BI-RADS categories, before breast US.

BI-RADS<sub>F</sub> is final BI-RADS categories, after breast US.

False negative rate of BI-RADS<sub>M</sub> categories was 7.68% (95%CI = 6.14 - 9.56) and of RECOM<sub>M</sub> was 2.59% (95%CI = 1.73-3.83). Table 3 displays percentage of patients with same and changed recommendation after breast US according to age groups, breast composition and availability of prior mammograms.

**Table 3.** Comparison of 1,003 patients with same and changed recommendation, according to age group, breast composition and availability of prior films.

	Same recommendation		Changed recommendation		Total	
	No.	%	No.	%	No.	%
Age group						
< 40 years	53	5.42	4	15.38	57	5.68
40-49 years	269	27.53	8	30.77	277	27.62
50-59 years	457	46.78	9	34.62	466	46.46
60-69 years	178	18.22	5	19.23	183	18.25
> 70 years	20	2.05	0	0	20	1.99
Total	977	100	26	100	1003	100
Breast composition						
Homogeneously dense	191	19.55	9	34.62	200	19.94
Heterogeneously dense	506	51.79	16	61.54	522	52.04
Scattered dense	216	22.11	1	3.85	217	21.64
Almost entirely fat	64	6.55	0	0.00	64	6.38
Total	977	100	26	100	1003	100
Prior mammograms						
No	509	52.10	24	92.31	533	53.14
Yes	468	47.90	2	7.69	470	46.86
Total	977	100	26	100	1003	100



## Discussion

In this study, most asymptomatic women with negative or benign findings on the screening mammographic films had no recommendation change following breast US. Upstage of BI-RADS categories is found in 7.68%, and recommendation change is found in only 2.59% after breast US. Since BI-RADS categories 1 and 2 have same recommendation, when breast US reveals benign findings such as breast cysts and intramammary lymph node, final BI-RADS category 2 will be assigned without recommendation change. Recommendation change is made when US reveals more suspicious findings and final BI-RADS categories are assigned into categories 3, 4 or 5. Previous reviews reported that about 90% of screening mammography are negative or benign<sup>(8)</sup> and screening breast US may leads to false-positive results which possibly requiring unnecessary biopsy.<sup>(9,10)</sup> Because only small proportion of women with negative or benign screening mammography had recommendation change after breast US in this study, along with the facts that most screening mammography are negative or benign, batch interpretation should be considered to be used instead of immediate interpretation in screening mammography and additional breast US should be performed only when screening mammography reveals suspicious abnormality or malignant findings.

This study demonstrated, as expected, that breast composition had significant effects on recommendation change and patients with dense breasts (i.e. homogeneously and heterogeneously dense breast compositions) about ten times more likely to have recommendation change following breast US than women with non-dense breasts (i.e.

scattered dense and almost entirely fatty breasts). Similarly, literatures about usage of breast US in various subject groups reported that clinically and mammographically occult breast cancers tend to occur in dense breasts and breast US is useful in demonstrating these cancers which were obscured by fibroglandular tissue on mammography.<sup>(2,11,12)</sup> While all women with fatty breasts in this study had negative breast US, similarly, another study also reported very few of mammographically missed breast cancer detected by US in fatty breasts.<sup>(12)</sup>

Women who did not have previous screening mammography for comparison were about eleven times more likely to receive recommendation change after breast US in this study. Demonstration of stability or regression of a suspicious area on current mammography compared previous films help increased confidence in assigning mammographic categories as BI-RADS 1 and 2. Several articles have established the value of comparing current screening mammography by reduction of false negative rate when subtle parenchymal changes identified.<sup>(13,14)</sup> Reduction of recall rate, about 50%, without reduction of cancer detection rate when present films are interpreted in comparison with previous films are reported.<sup>(8,15-18)</sup> In this study, 2 of 26 women with recommendation change had previous mammography with interval duration of mammography ranged from 26 to 36 months. Current films of both women revealed no detectable change as compared to previous films. Since there were only two cases of this condition, evaluation of time interval effect on recommendation change cannot be performed.

After controlling effects of breast composition and availability of prior mammography for comparison, age did not show significant influence on recommendation change. This is similar to those of earlier literatures that reported no significant effect of age on sensitivity of screening mammography.<sup>(19, 20)</sup>

There are some limitations in this study. First, this is retrospective study; mammographic BI-RADS categories did not assigned by the attending radiologists but retrospectively assigned by the researcher based on mammographic films and reports. Second, breast US is operator-dependent imaging that requires real-time recognition of abnormalities and these US were performed by radiologists with knowledge of mammographic result. Therefore, the radiologists may have been influenced by the level of suspicion from mammographic result. Third, there is no suspicious abnormality or highly suggestive of malignant findings from breast US in this review, which is lower than average cancer detection rate (0.3%).<sup>(21)</sup> This may resulted from operator-dependency of US as previously discussed. To overcome limitations in this study, further prospective control studies in larger population group to study benefit of breast US in asymptomatic women with negative or benign screening mammography may be very useful.

## Conclusion

The findings in the study suggest lack of necessity for performing additional US in women with negative or benign findings on screening mammography, particularly in women with scattered dense breasts or almost entirely fatty breasts and

in women with prior mammography available for comparison. Because of increasing demand for breast cancer screening and inadequate manpower, one practical application of these data is to use batch interpretation in screening mammographic service instead of immediate interpretation and skip performing breast US in asymptomatic women with mammographic BI-RADS categories 1 and 2 who are in non-dense breast group or who have previous films for comparison. These should increase efficiency and cost-effectiveness of screening mammography service. However, in women in dense breast group and in women whose interval mammographic films are not available, in spite of negative or benign mammographic findings, additional breast US is still necessary.

## Acknowledgement

The author would like to thanks Dr. Piyanit Tharmaphornpilas for her invaluable assistance.

## References

1. Smith RA, Duffy SW, Gabe R, Tabar L, Yen AM, Chen TH. The randomized trials of breast cancer screening: what have we learned? Radiol Clin North Am 2004 Sep;42(5):793-806
2. Kopans DB. What is a useful adjunct to mammography? Radiology 1986 Nov;161(2):560-1
3. D'Orsi CJ, Bassett LW, Berg WA, Feig SA, Jackson VP, Kopans DB, Linver MN, Mendelson EB, Moss LJ, Sickles, EA. Reporting system. In: American College of Radiology. Breast Imaging Reporting and Data System (BI-RADS). 4<sup>th</sup> ed. Reston, VA: American Col

- lege of Radiology, 2003: 177-228
4. Burnside ES, Park JM, Fine JP, Sisney GA. The use of batch reading to improve the performance of screening mammogram. *AJR Am J Roentgenol* 2005 Sep;185(3):790-6
  5. Ghate SV, Soo MS, Baker JA, Walsh R, Gimenes EI, Rosen EL. Comparison of recall and cancer detection rates for immediate versus batch interpretation of screening mammogram. *Radiology* 2005 Apr;235(1): 31-5
  6. Feig SA. Economic challenges in breast imaging. A survivor's guide to success. *Radiol Clin N Am* 2000 Jul;38(4):843-52
  7. Hendrick RE, Cutter GR, Berns EA, Nakano C, Egger J, Carney PA, Abraham L, Taplin SH, D'Orsi CJ, Barlow W, et al. Community-based mammography practice: services, charges, and interpretation method. *AJR Am J Roentgenol* 2005 Feb;184(2):433-8
  8. Farria DM, Monsees B. Screening mammography practice essentials. *Radiol Clin North Am* 2004 Sep;42(5):831-43
  9. Kopans DB, Meyer JE, Lindfors KK. Whole-breast US imaging: four-year follow-up. *Radiology* 1985 Nov;157(2):505-7
  10. Berg WA. Supplemental screening sonography in dense breasts. *Radiol Clin North Am* 2004 Sep;42(5):845-51
  11. Kolb TM, Lichy J, Newhouse JH. Occult Cancer in women with dense breasts: Detection with screening US - Diagnostic yield and tumor characteristics. *Radiology* 1998 Apr; 207(1):191-9
  12. Berg WA, Gilbreath PL. Multicentric and multifocal cancer: Whole-breast US in preoperative evaluation. *Radiology* 2000 Jan; 214(1):59-66
  13. Bassett LW, Shayestehfar B, Hirbawi I. Obtaining previous mammograms for comparison: usefulness and costs. *AJR Am J Roentgenol* 1994 Nov ;163(5):1083-6
  14. Leconte I, Feger C, Galant C, Berliere M, Berg BV, D'Hoore W, Maldague B. Mammography and subsequent whole-breast sonography of nonpalpable breast cancers: the importance of radiologic breast density. *AJR Am J Roentgenol* 2003 Jun;180(6):1675-9
  15. Frankel SD, Sickles EA, Curpen BN, Sollitto RA, Ominsky SH, Galvin HB. Initial versus subsequent screening mammography: comparison of findings and their prognostic significance. *AJR Am J Roentgenol* 1995 May;164(5):1107-9
  16. Sumkin JH, Holbert BL, Herrmann JS, Hakim CA, Ganott MA, Poller WR, Shah R, Hardesty LA, Gur D. Optimal reference mammography: a comparison of mammograms obtained 1 and 2 years before the present examination. *AJR Am J Roentgenol* 2003 Feb;180(2): 343-6
  17. Burnside ES, Sickles EA, Sohlich RE, Dee KE. Differential value of comparison with previous examinations in diagnostic versus screening mammography. *AJR Am J Roentgenol* 2002 Nov;179(5): 1173-7
  18. Hunt KA, Rosen EL, Sickle EA. Outcome analysis for women undergoing annual versus biennial screening mammography: a review of 24,211 examination. *AJR Am J Roentgenol*

1999 Aug;173(2):285-9

19. Rosenber RD, Hunt WC, Williamson MR, Gilliland FD, Wiest PW, Kelsey CA, Key CR, Linver MN. Effects of age, breast density, ethnicity, and estrogen replacement therapy on screening mammographic sensitivity and cancer stage at diagnosis: Review of 183,134 screening mammograms in Albuquerque, New Mexico. Radiology 1998 Nov;209(2):511-8

20. Curpen BN, Sickles EA, Sollitto RA, Ominsky SH, Galvin HB, Frankel SD. The comparative value of mammographic screening for women 40-49 years old versus women 50-64 years old. AJR Am J Roentgenol 1995 May;164(5): 1099-103

21. Kaplan SS. Clinical utility of bilateral whole-breast US in the evaluation of women with dense breast tissue. Radiology 2001 Dec;221(3): 641-9