Abbreviated Breast MRI (ABMR) for Breast Cancer Screening

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SNUH **RADIOLOGY**

SEOUL NATIONAL UNIVERSITY
HOSPITAL

Disclosure

- **Bayer Research Grant (Gadovist_20136)**

- **National R&D Program for Cancer Control, Korea (1720370)**

- **Korean Society of Breast Imaging & Korean Society For Breast Screening**

Objectives

- **Discuss the role of an breast MRI as a screening tool**

- **Discuss the concept of an abbreviated breast MRI (ABMR) examination**

- **Discuss the results of ABMR screening and ongoing trials**

Outline

- **Supplemental Screening Methods**

- **The Concept and Results of ABMR**

- **The Korean ABMR Study in Women with BRCA Testing**

- **Outlook for Fast and Low-Cost MR for Breast Cancer Screening**

Supplemental Screening

Anatomic

- Tomosynthesis (DBT, "3D mammography")
- Ultrasound (US)

Functional

- MRI (Abbreviated MR)
- Contrast enhanced mammography
- Gamma/PET imaging

Comparison of Supplemental Methods

Modality	Incremental CDR	PPV3	Interval cancer	Cost	Radiation
DBT	1-2	29%	↓29%	$$	☢ (x1.2-2 than mammo)
US	2-4	9%	↓50%	$$	No
MRI	14+	27%	↓99%	$$$$	No
CESM	Not determined		Not determined	$$$	☢
MBI	7-8	33%	Not determined	$$$	☢ ☢ ☢ ☢ (x8-30 than mammo)

Hooley RJ, et al. RCNA 2017

ACRIN 6666 Trial

Detection of Breast Cancer With Addition of Annual Screening Ultrasound or a Single Screening MRI to Mammography in Women With Elevated Breast Cancer Risk

Scan for Author Audio Interview

Wendie A. Berg, MD, PhD
Zheng Zhang, PhD
Daniel Lehrer, MD
Roberta A. Jong, MD
Etta D. Pisano, MD
Richard G. Barr, MD, PhD
Marcela Böhm-Vélez, MD
Mary C. Mahoney, MD
W. Phil Evans III, MD
Linda H. Larsen, MD
Marilyn J. Morton, DO
Ellen B. Mendelson, MD
Dione M. Farria, MD

Context Annual ultrasound screening may detect small, node-negative breast cancers that are not seen on mammography. Magnetic resonance imaging (MRI) may reveal additional breast cancers missed by both mammography and ultrasound screening.

Objective To determine supplemental cancer detection yield of ultrasound and MRI in women at elevated risk for breast cancer.

Design, Setting, and Participants From April 2004-February 2006, 2809 women at 21 sites with elevated cancer risk and dense breasts consented to 3 annual independent screens with mammography and ultrasound in randomized order. After 3 rounds of both screenings, 612 of 703 women who chose to undergo an MRI had complete data. The reference standard was defined as a combination of pathology (biopsy results that showed in situ or infiltrating ductal carcinoma or infiltrating lobular carcinoma in the breast or axillary lymph nodes) and 12-month follow-up.

Main Outcome Measures Cancer detection rate (yield), sensitivity, specificity, positive predictive value (PPV3) of biopsies performed and interval cancer rate.

Results A total of 2662 women underwent 7473 mammogram and ultrasound screenings, 110 of whom had 111 breast cancer events: 33 detected by mammography only, 32 by ultrasound only, 26 by both, and 9 by MRI after mammography plus ultrasound; 11

- Additional cancer yield by HHUS: 4.1 per 1000
  - Interval cancer rate: 8%
  - Mean radiologist time: 21 min
- Additional cancer yield by a single MRI: 14.6 per 1000

Berg WA, et al. JAMA 2008 ; JAMA 2012

Breast Cancer Risk Stratification

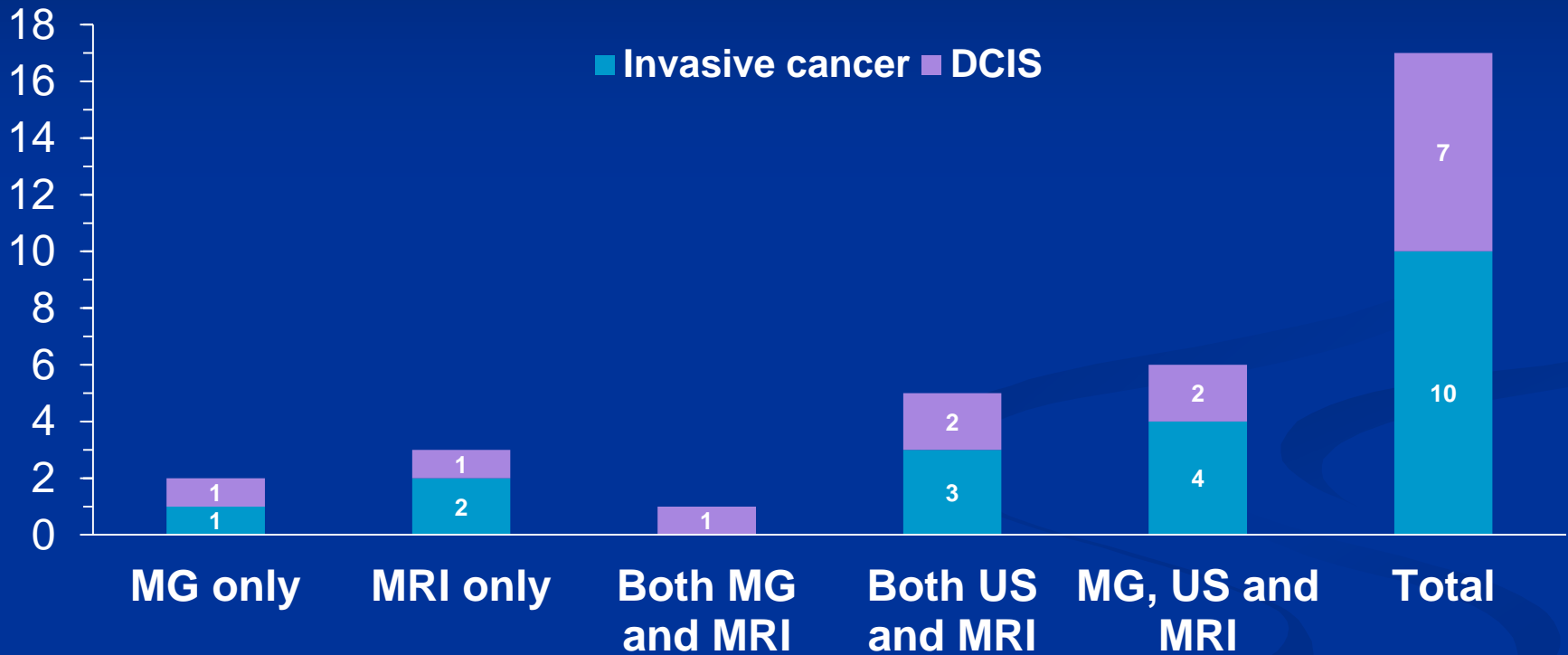|	Lifetime Risk	Associated Risk Factors
Average Risk	**< 15%**	• **Dense breast tissue**
Moderate Risk	**15 – 20%**	• Prior breast cancer • **LCIS, ADH, ALH** • **Intermediate family history** • **Dense breast tissue**
High Risk	**> 20%**	• **Hereditary Breast and Ovarian Cancer syndrome (e.g. BRCA 1/2)** • **Other genetic mutations** • **Chest radiation at a young age**

Screening in Women Treated with Conservation Therapy at ≤ 50 Years

- A prospective, multicenter, nonrandomized comparison study between December 2010 and January 2016 at 6 academic institutions

- In younger women who had undergone breast conservation, the addition of MRI screening or US to mammography can be considered.

Cho N, et al. JAMA Oncol. 2017 June

Screening in Women Treated with Conservation Therapy at ≤ 50 Years

No. of Detected Cancers in 754 Women

Legend: ■ Invasive cancer ■ DCIS

Category	Invasive cancer	DCIS
MG only	1	1
MRI only	2	1
Both MG and MRI		1
Both US and MRI	3	2
MG, US and MRI	4	2
Total	10	7

Sensitivity of digital MG, US and MRI is 53%, 65% and 88%. (50%, 70% and 90% for invasive cancer)

Cho N , et al. JAMA Oncol. 2017 June

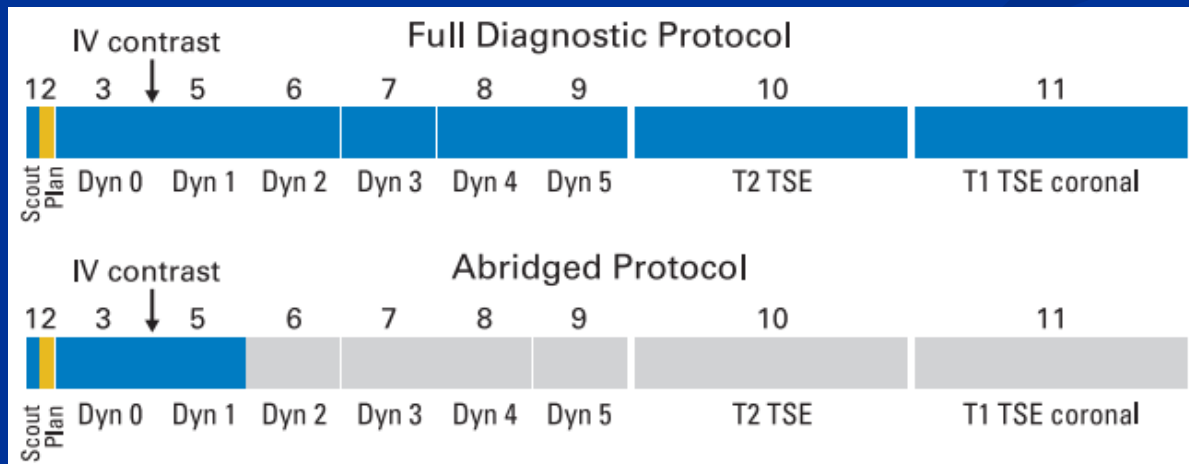# Second Breast Cancer in Women with BRCA Mutation

- Of the 754 women, 61 (8.1%) underwent genetic testing and 17 (2.3%, positivity rate 27.9%) were found to be BRCA mutation carriers, and 2 (12%) of the 17 had second breast cancers.

- For contralateral breast cancer, the cumulative risk 20 years after breast cancer diagnosis was 40% (95% CI, 35%-45%) for BRCA1 and 26% (95% CI, 20%-33%) for BRCA2 carriers*.

Breast MRI Screening

- High-risk women with BRCA1/2 mutation or cumulative lifetime risk over 20% based on familial history of any breast density

- Women with personal history of breast cancer according to a multicenter prospective study in Korea*

- High cost, long image acquisition and interpretation time, and accessibility are major detriments

*ACR 2018 Guideline

Abbreviated Breast MRI

- a prospective observational reader study in 443 women at moderately or highly increased risk

- 3 minutes' scan time

- 10 sec reading time (MIP 2.8 s, AP 28 s)

- No loss of cancer detection (18/1000) and no significant increase in false positives (PPV 24.4%)
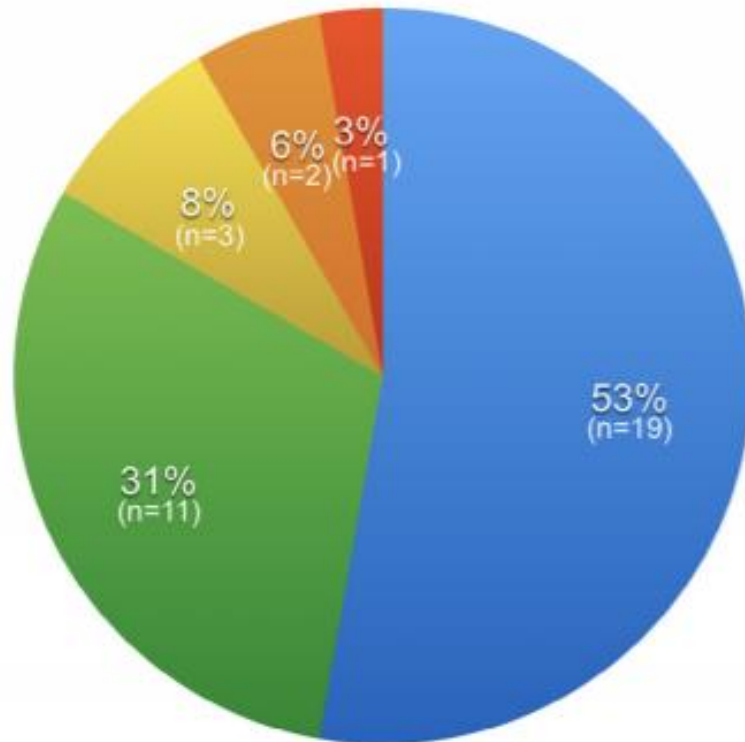
	Full Diagnostic Protocol							
IV contrast								
12	3	5	6	7	8	9	10	11
Scout Plan	Dyn 0	Dyn 1	Dyn 2	Dyn 3	Dyn 4	Dyn 5	T2 TSE	T1 TSE coronal

17 minutes

	Abridged Protocol							
IV contrast								
12	3	5	6	7	8	9	10	11
Scout Plan	Dyn 0	Dyn 1	Dyn 2	Dyn 3	Dyn 4	Dyn 5	T2 TSE	T1 TSE coronal

3 minutes

Kuhl C, et al. J Clin Oncol 2014

An Abbreviated Protocol for High-Risk Screening Breast MRI

Full vs. abbreviated breast MRI protocol

1052 cases	Full protocol	Abbreviated protocol
Magnet time	24 minutes	3 minutes
Cancer detection rate	13.3 cancers per 1,000	13.3 cancers per 1,000
Sensitivity	81.8%	81.8%
Specificity	97.4%	97.2%
PPV3	30.4%	31.1%

Panigrahi B, Harvey S et al, Acad Radiol. 2017 Sep

BIRADS Changes between Abbreviated and Full Protocols (n = 36, 3.4%)

		53% (n=19)

Pie chart:
- 53% (n=19)
- 31% (n=11)
- 8% (n=3)
- 6% (n=2)
- 3% (n=1)

		Full Protocol BI-RADS					
		B0	B1	B2	B3	B4	B5
Abbreviated protocol BI-RADS	B0	19	2	9	8	0	0
	B1	1	274	4	0	0	0
	B2	1	0	648	3	1	0
	B3	1	0	4	30	0	0
	B4	0	0	0	2	44	0
	B5	0	0	0	0	0	1

1052 cases

- ● Full protocol deferred additional imaging (B0 → B1-3)
- ● Full protocol did not alter biopsy decision (B1-3 → B1-3)
- ● Full protocol recommended additional imaging (B1-3 → B0)
- ● Full protocol deferred biopsy (B4 → B3)*
- ● Full protocol recommended biopsy (B2 → B4)**

Panigrahi B, Harvey S et al, Acad Radiol. 2017 Sep

EA1141 Study Schema

To compare the rates of detection of invasive cancers between the initial AB-MR and DBT

Women ages 40-75 with dense breasts already scheduled for routine screening DBT

Ⓡ

Arm A (DBT first)
Years 0 and 1
DBT followed by AB-MR

Arm B (AB-MR first)
Years 0 and 1
AB-MR followed by DBT

Return to routine mammographic screening and follow for 3 years
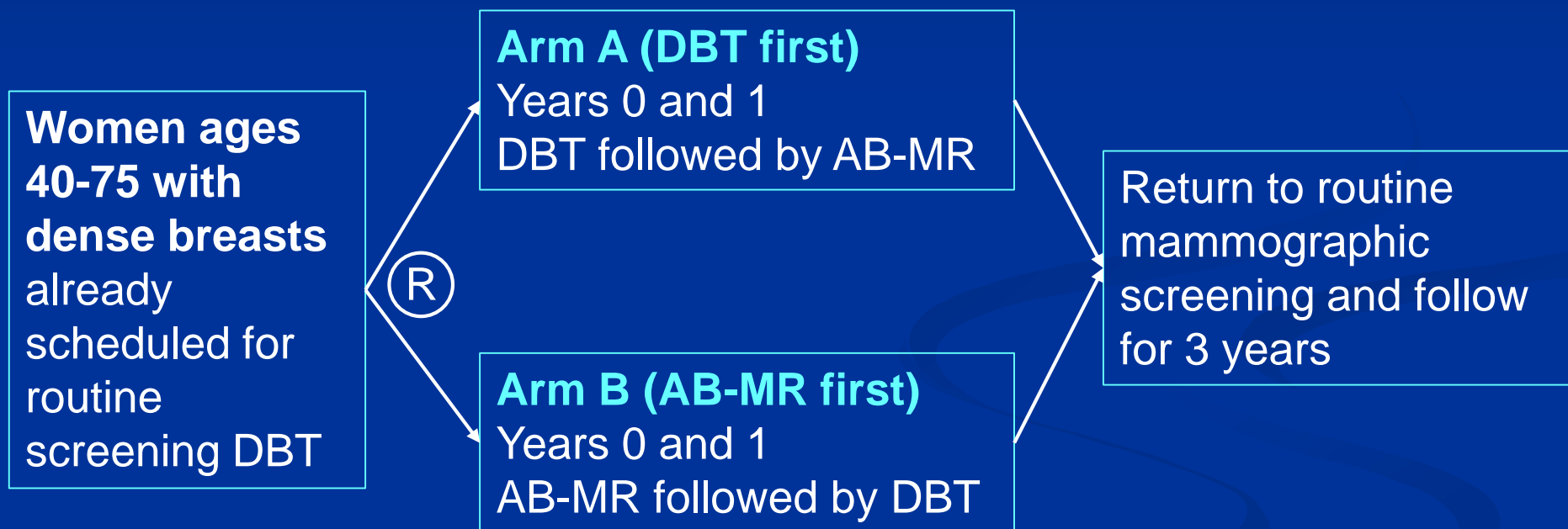
Accrual Goal = 1,450
AB-MR protocol includes 1 pre- and 1 post-contrast T1WI plus T2WI

MRI surveillance for women with a personal history of breast cancer: comparison between Abbreviated and Full diagnostic protocol

Sol Bee Han · Eun Young Ko · Boo Kyung Han · Eun Sook Ko · Ji Soo Choi · Ko Woon Park

Department of Radiology, Samsung Medical Center, Sungkyunkwan University School of Medicine

SAMSUNG   SAMSUNG MEDICAL CENTER
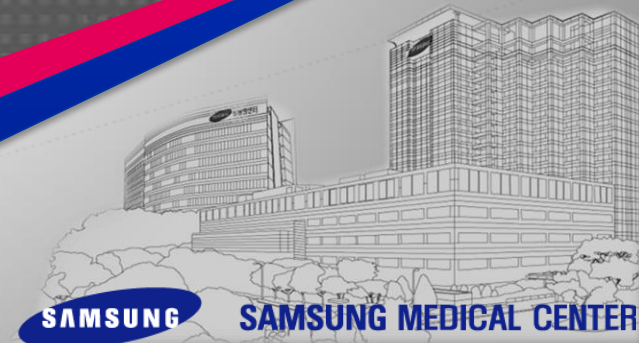
Breast MRI Protocol - FDP

** Scan time: 25~27 min

Scanning	Series of images	Plane
T1 without fat saturation	T1 without fat saturation	Axial
T2 with fat saturation	T2 with fat saturation	Axial
DWI	DWI, ADC map	Axial
T1 Contrast enhanced Dynamic 3D with fat sat (THRIVE) - pre CE - post CE 1st - post CE 2nd - post CE 3rd - post CE 4th - post CE 5th - post CE 6th	3D Contrast enhanced Dynamic images (pre, post 1min~7min)	Axial
	Standard Subtraction - 1st – pre - 2nd - pre	Axial
	Reversed Subtraction - 1st – 6th - 2nd – 6th	Axial
	MIP, both	Axial, Sagittal
	MPR (2nd post CE) both	Sagittal
Delayed T1 FS CE (axilla)	T1 with fat saturation	Axial

Korean ABMR Study in Women with BRCA Testing

- **15 academic and community centers in Korea**

  SNUH, Asan MC, Samsung MC, Severance Hospital, National Cancer Center, Gangnam Severance Hospital, Kangbuk Samsung Hospital, Korea Cancer Center Hospital, Korea University Guro Hospital, Ewha Womans University Mokdong Hospital, SMG-SNU Boramae MC, Ajou University MC, SNU Bundang Hospital, Chonnam NU Hwasun Hospital

- **To evaluate the outcome of second breast cancer surveillance with ABMR or ultrasound in addition to annual mammography in women with BRCA1/2 mutation testing**

ClinicalTrials.gov Identifier: NCT03475979

Eligibility Criteria

- Women aged between 25 years and 69 years at the time of initial breast cancer diagnosis

- BRCA mutation test indicated:

  1) early-age-onset breast cancer (40 years or younger)

  2) bilateral breast cancers (synchronous)

  3) personal history of ovarian cancer and/or other multiple primary cancer,

  4) family history of breast and/or ovarian cancer in first- or second-degree relatives

ClinicalTrials.gov Identifier: NCT03475979

Eligibility Criteria

- Bilateral mastectomy not done (who has remnant breast tissue)

- No prior MRI, US, mammography, or breast biopsy within 6 months prior to this study

- No symptom or sign of secondary breast cancer at the time of enrollment

- No contraindications to breast MRI with contrast enhancement

ABMR for Second Breast Cancer Detection in Women With BRCA Mutation

- AB-MR, US, and digital mammography will be performed on the same day and interpreted independently at baseline and then after 1 year.

- After completion of study, patients are followed-up for at least 1 year.

Diagnosis of First Breast Cancer in Women Aged 25-69yrs

Risk Assessment | Genetic Counseling

BRCA Testing in Women with a High Mutation Risk

- Breast cancer diagnosis ≤ 40 yrs
- Bilateral breast cancer or ovarian cancer
- 1st or 2nd degree FHx(+) of breast or ovarian cancer

Noncarrier | **BRCA1 mut(+)** | **BRCA2 mut(+)**

Counseling for Treatment | Counseling for Treatment | Counseling for Treatment

Surgery and Adjuvant Therapy

연구 동의 및 검사 시작 ⟶ Bilateral Mastectomy Excluded

1st round screening (start within 5 yrs after surgery)

Mammography, Ultrasound, Breast MRI
- Independent reading using BI-RADS
- Combined reading (MG+US, MG+MR, MG+US+MR)

2nd round screening

Mammography, Ultrasound, Breast MRI
- Independent reading using BI-RADS
- Combined reading (MG+US, MG+MR, MG+US+MR)

1 y Follow-up and Outcome Analysis

March 2022

ABMR for Second Breast Cancer Detection in Women With BRCA Mutation

- To compare the CDR, PPV, and NPV of ABMR, US, and mammography

- To describe the histologic type, tumor grade, and molecular tumor subtype of secondary breast cancers detected at ABMR, US, and mammography

ClinicalTrials.gov Identifier: NCT03475979

ABMR Protocol

No.	Recommendation	
Equipment & Position		
1	≥1.5T (Siemens Skyra 3.0T & Philips Ingenia CX 3.0T)	
2	Dedicated bilateral breast coil	
3	Prone position	
4	Contrast medium: Gadolinium (Gadovist) administered via an IV catheter inserted in the arm or hand using a power injector at a dose of 0.1 mmol/kg body weight and a rate of 2 ml/sec, followed by a 20 ml saline flush	
Image Acquisition : magnet time ≤10min (9min in both Skyra and Ingenia)		
1	A localization scan	
2	Axial T2 (with fat saturated)	Slice thickness ≤1.5mm (1-1.5mm for T2, 1.0mm for T1); No gap; In-plane resolution ≤1mm
3	Axial PreT1 (with fat saturated)	
4	Axial PostT1 (with fat saturated, within 2 min)	
5	Axial Subtraction (PostT1-PreT1)	Derived images
6	Axial Subtraction MIP	
7	Sagittal PostT1 MPR	
8	Sagittal Subtraction MIP	

Society of Breast MRI

Home | For Members | Meetings | Training | Research | Contact

Since 2014
Society of Breast MRI
SBMR

Training

Abbreviated Breast MRI Reader Training and Certification

The goal of AB-MR interpretation is to maintain high sensitivity and specificity. In order to minimize false positives and short term follow-ups, it is fundamental to focus only on findings that are truly unique to the background parenchymal enhancement (BPE).

1) Review the AB-MR interpretation algorithms*
2) Study the reader training material
3) Review the test instructions and user manual
4) Take the 50 case AB-MR interpretation certification test.

*** You do not have to complete the test in a single session. If you logout, your progress will be saved and you can return to the test multiple times until it is complete ***

TEST VIEWER SYSTEM REQUREMENTS:
- High speed internet connection is required (30 Mbps or higher is preferred).
- 17inch or larger monitor and mouse with wheel function is preferable.
- Internet Explorer is not fully supported. Modern versions of Internet Explorer on Windows 7 and above will work, however, performance may be greatly diminished.
- Consider using Firefox or Chrome internet browsers.

Certification Test Instructions and User Manual

AB-MR Certification Test Login

AB-MR Interpretation Algorithms*

AB-MR Reader Training Material

Test Instructions and User Manual

AB-MR Interpretation Certification Test Login

EA1141 Study

QUANTITATIVE INSIGHTS

*The Society of Breast MRI Interpretation Guidelines suggests a standardized method for abbreviated breast MRI interpretation. These algorithms are not meant to dictate individual case management decisions. The ultimate decision regarding AB-MR interpretation must be made by the interpreting radiologist in light of all the circumstances presented in an individual examination.

ABMR Interpretation Algorithms

Not Op Site (including contralateral breasts)

- **Baseline MR***
  - ✓ **Focus**
  - ✓ **Mass**
  - ✓ **NME**

- **Follow-up MR**
  - ✓ **No change or ↓ in Size of Lesion**
  - ✓ **Increase in Size of Lesion**
  - ✓ **New Lesion**

* http://www.societyofbreastmri.org/Training.html

ABMR Interpretation Algorithms

Op Site (or Reconstructed flap)
: Fat necrosis vs. Local recurrence

- Baseline MR

Daly CP, et al. AJR 2008
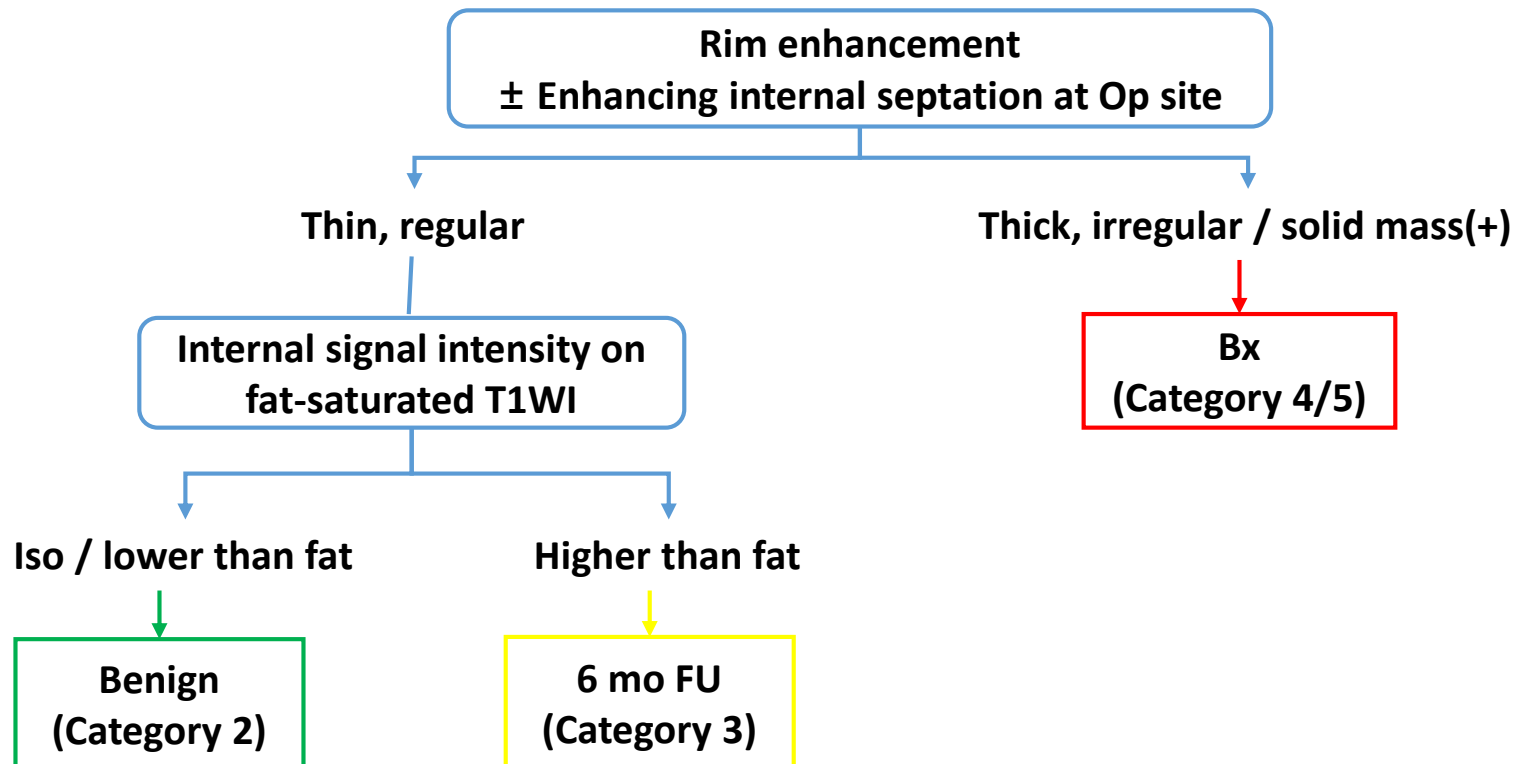
Novel Approaches to Fast and Low-Cost Breast MRI for Screening

- MRI screening within 2 min. with Ultrafast dynamic scan

- MRI screening without contrast agent such as diffusion-weighted imaging and ADC map

  : Fused DWI (High b-value DWI with

  Unenhanced T1WI) and MIP

Ultrafast Breast DCE-MRI

- Whole breast 3D data at multiple time points with high temporal resolution (4.3 – 7.0 sec)

- Kinetic information in the early phase

- Time to enhancement (TTE) derived from ultrafast breast MRI as a novel parameter to discriminate benign from malignant breast lesions

Abe H, et al. AJR 2016; 207:1159   Mus RD, et al. EJR 2017; 89:90

Ultrafast vs Conventional DCE-MRI
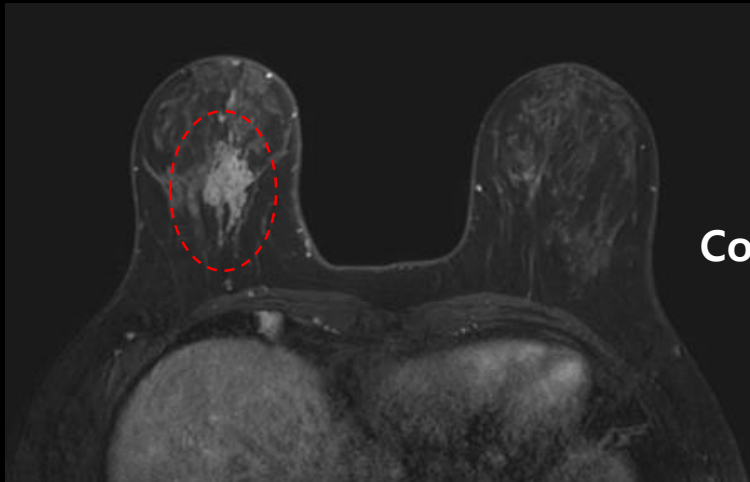
Conventional Phase 1

90 sec

Ultrafast Phase 8

36 sec
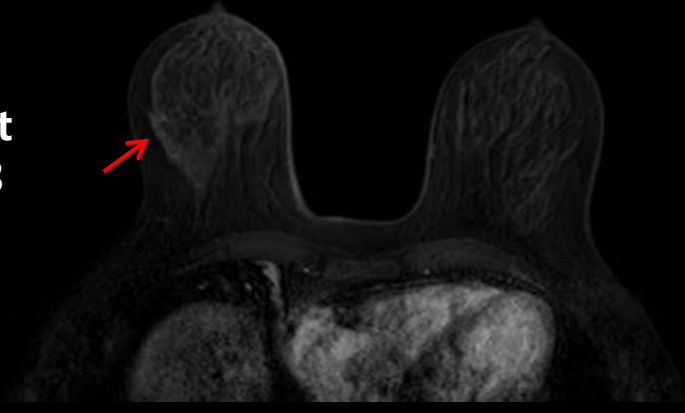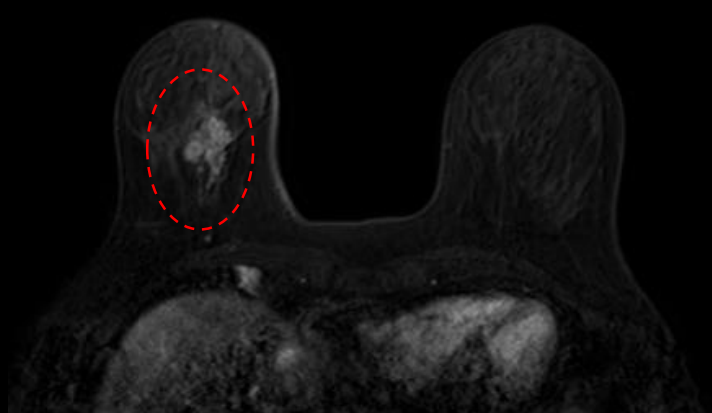
Rt 6h, 6.8x1.6x2.4cm mass and segmental NME (C6)   Rt 8h, 4.2cm clumped linear NME (C4)
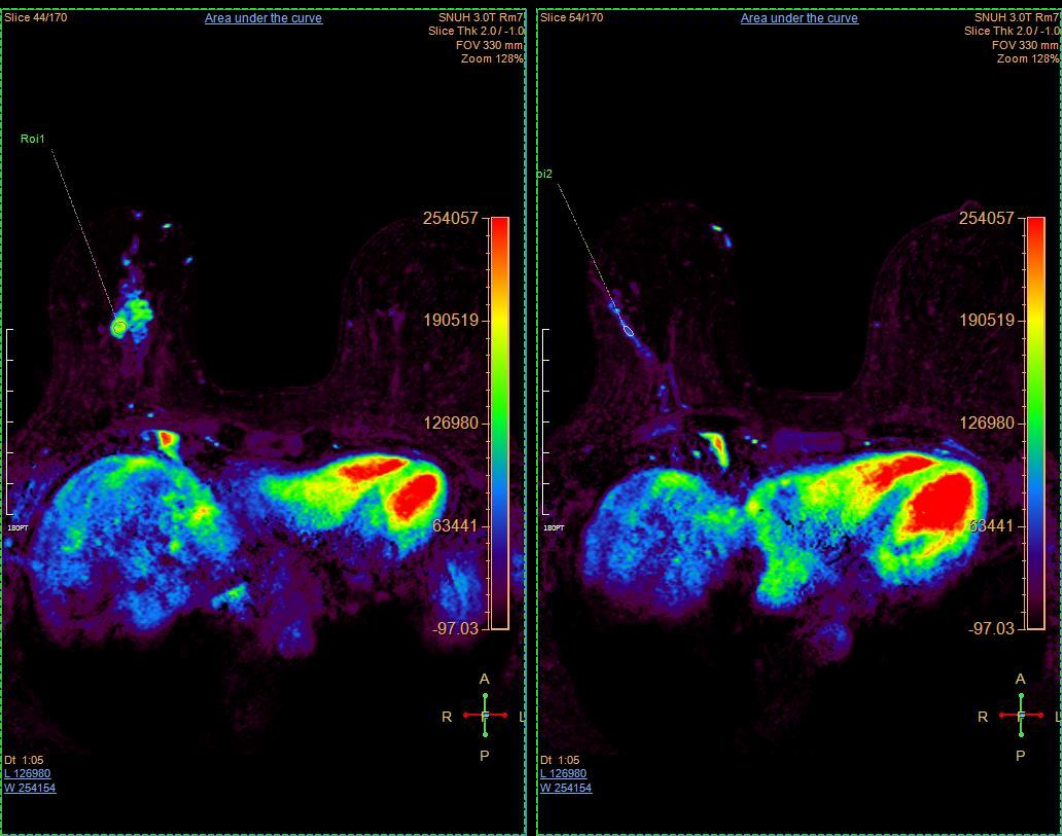
ROI 1 (C6)
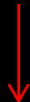
ROI 2 (C4)

IDC with DCIS

Usual Ductal Hyperplasia

Sung UI Shin, et al. 2017 RSNA
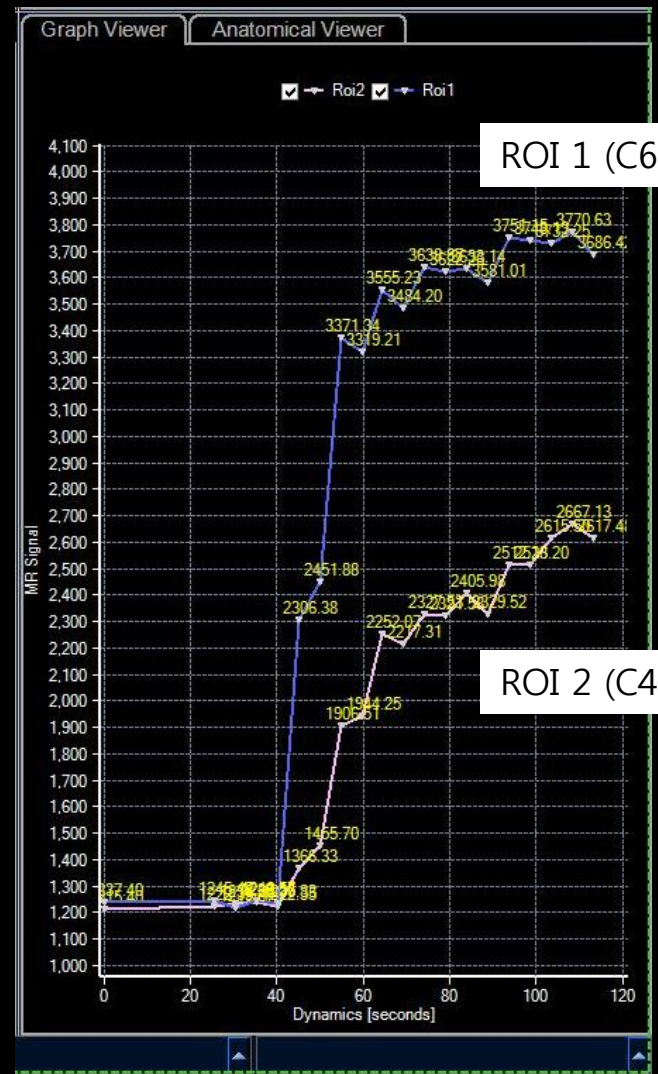
Initial Evaluation of Ultra FAST Breast MRI in Breast Cancer Screening: Comparative Study With Mammography and Ultrasound
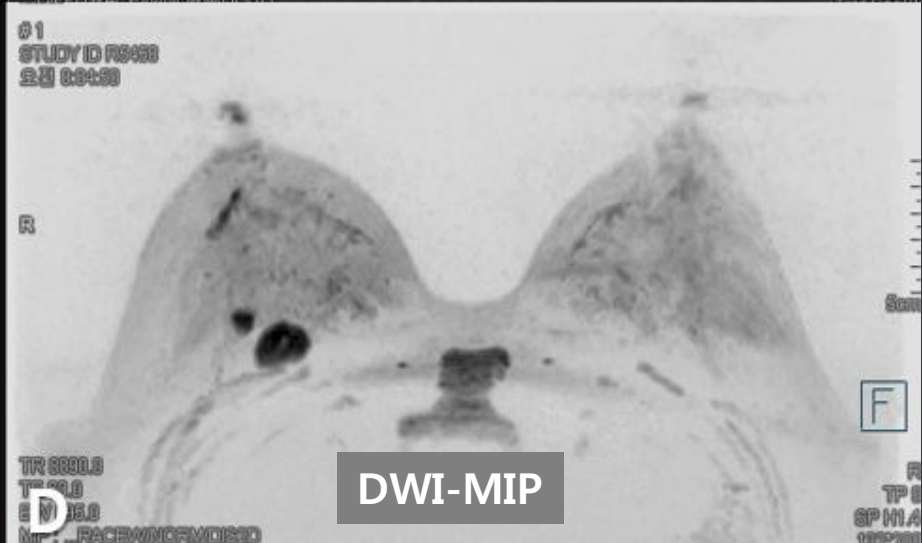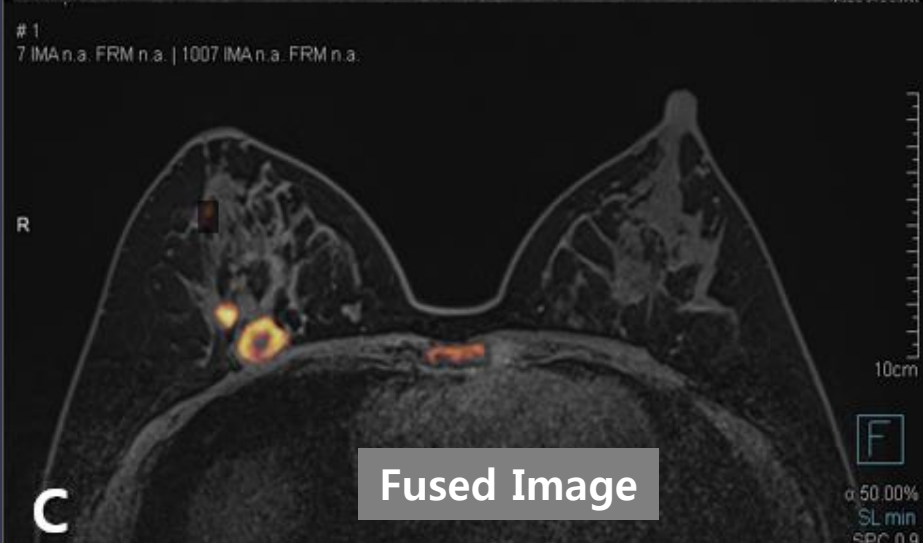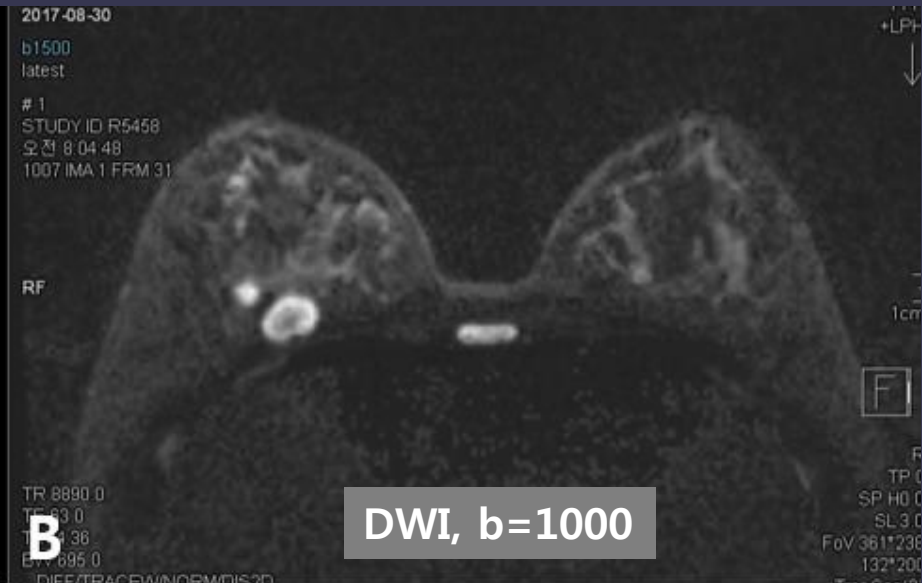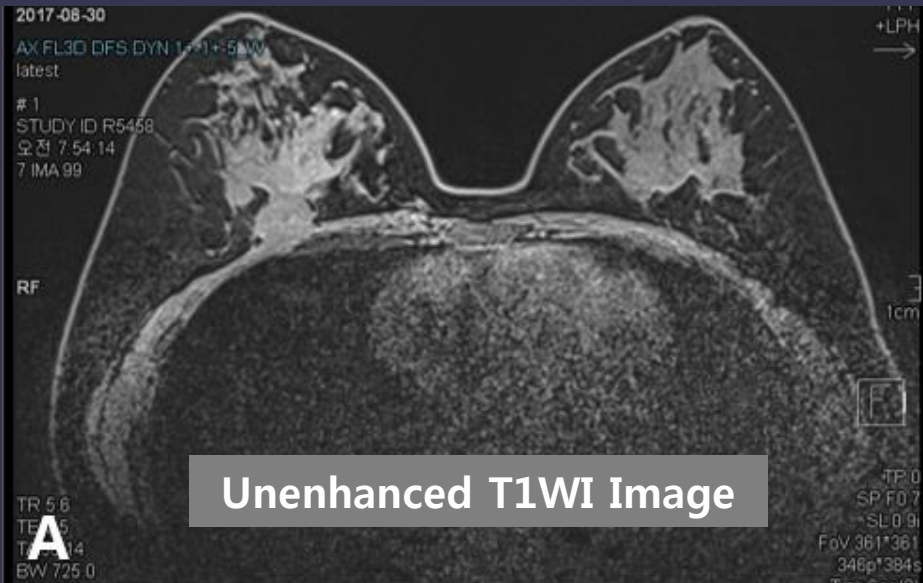
- Interventional

- The normal eligible screening population will first undergo a mammography, then an echography screening followed by a fast MRI screening.

- 1000 participants

- 30 Years and older

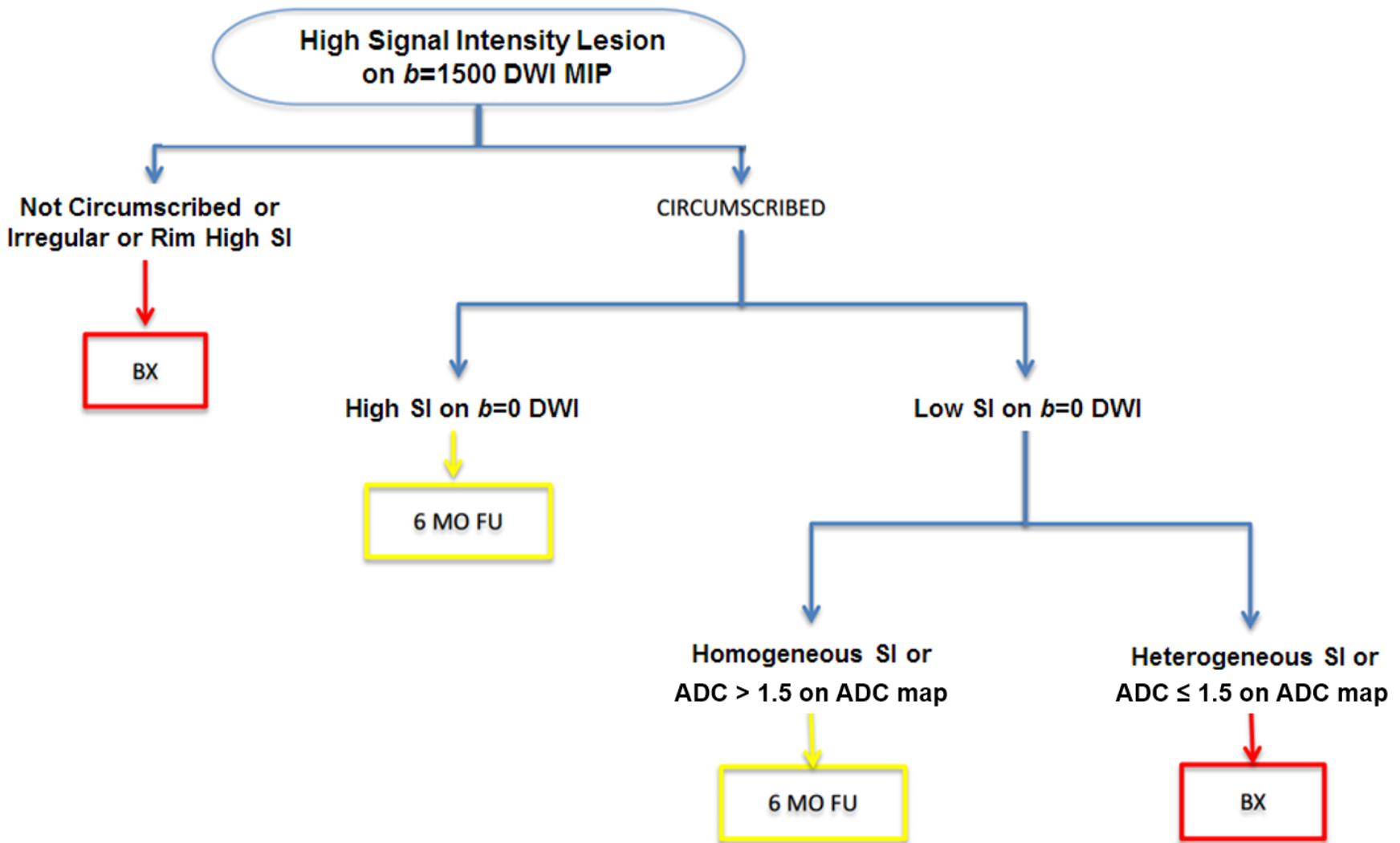- Brugmann University Hospital (Brussels, Belgium)

Breast DWI

- Noncontrast and Fast MR imaging technique

- Identifying early response in tumors undergoing NAC

- Can assist in differentiating benign & malignant lesions

- A noncontrast adjunct screening modality- Technical challenges
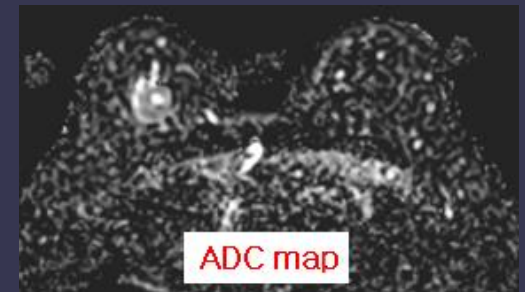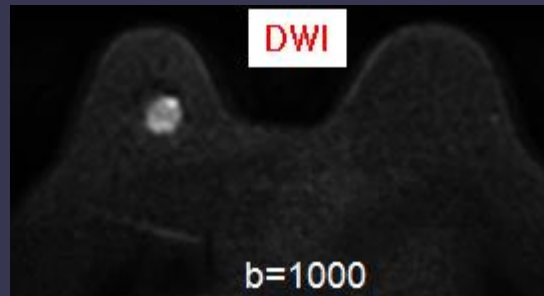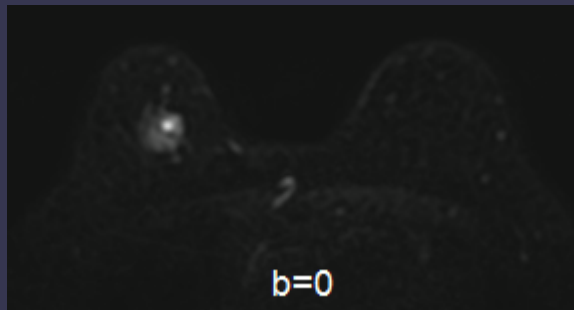
ASAN Medical Center

Fused DWI (High b-value DWI with Unenhanced T1WI) and MIP

Unenhanced T1WI Image

DWI, b=1000

Fused Image

DWI-MIP

Shin HeeJung

ASAN Medical Center

Interpretation Algorithm

Shin HeeJung

ASAN Medical Center

Breast Cancer Screening with Fused DWI: A Korean Multi-center Prospective Study

- A prospective multicenter observational cohort study to compare the sensitivity, specificity, PPV, and NPV of fused DWI & standard DCE-MRI (or ABMR+ fused DWI vs standard DCE-MRI)

- 1000 women at high risk for breast cancer

- Anticipated Study Start Date : November 2018

ABMR for Breast Cancer Screening: Conclusion

- ABMR protocol demonstrates effective performance in cancer detection comparable to full protocol.

- ABMR holds promise for resource-efficient breast cancer screening in intermediate- and high-risk women.

- The results of EA1141 study will answer the effectiveness of ABMR in average-risk women with dense breasts.

- Ultrafast dynamic MRI and fusion DWI without contrast may have potential as a rapid screening tool.

SNUH Breast Imaging Team (2015 Aug)