Abbreviated Breast MRI (ABMR) for Breast Cancer Screening

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Disclosure

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- 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

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

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

- 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

# Breast Cancer Risk Stratification

<table>
<thead>
<tr>
<th>Lifetime Risk</th>
<th>Associated Risk Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average Risk</strong></td>
<td>&lt; 15%</td>
</tr>
</tbody>
</table>
| **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

- 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*.

Kuchenbaecker KB, et al. JAMA. 2017 June
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%)

An Abbreviated Protocol for High-Risk Screening Breast MRI

<table>
<thead>
<tr>
<th>1052 cases</th>
<th>Full protocol</th>
<th>Abbreviated protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Magnet time</strong></td>
<td>24 minutes</td>
<td>3 minutes</td>
</tr>
<tr>
<td><strong>Cancer detection rate</strong></td>
<td>13.3 cancers per 1,000</td>
<td>13.3 cancers per 1,000</td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
<td>81.8%</td>
<td>81.8%</td>
</tr>
<tr>
<td><strong>Specificity</strong></td>
<td>97.4%</td>
<td>97.2%</td>
</tr>
<tr>
<td><strong>PPV3</strong></td>
<td>30.4%</td>
<td>31.1%</td>
</tr>
</tbody>
</table>

Panigrahi B, Harvey S et al, Acad Radiol. 2017 Sep
BIRADS Changes between Abbreviated and Full Protocols (n = 36, 3.4%)

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

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

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

*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
<table>
<thead>
<tr>
<th>Scanning</th>
<th>Series of images</th>
<th>Plane</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>T1 without fat saturation</strong></td>
<td><strong>T1 without fat saturation</strong></td>
<td><strong>Axial</strong></td>
</tr>
<tr>
<td><strong>T2 with fat saturation</strong></td>
<td><strong>T2 with fat saturation</strong></td>
<td><strong>Axial</strong></td>
</tr>
<tr>
<td><strong>DWI</strong></td>
<td><strong>DWI, ADC map</strong></td>
<td><strong>Axial</strong></td>
</tr>
<tr>
<td><strong>T1 Contrast enhanced Dynamic</strong></td>
<td><strong>3D Contrast enhanced Dynamic images (pre, post 1min~7min)</strong></td>
<td><strong>Axial</strong></td>
</tr>
<tr>
<td>3D with fat sat (THRIVE)</td>
<td><strong>Standard Subtraction</strong></td>
<td><strong>Axial</strong></td>
</tr>
<tr>
<td>- pre CE</td>
<td>- 1&lt;sup&gt;st&lt;/sup&gt; – pre</td>
<td></td>
</tr>
<tr>
<td>- post CE 1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>- 2&lt;sup&gt;nd&lt;/sup&gt; – pre</td>
<td></td>
</tr>
<tr>
<td>- post CE 2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td><strong>Reversed Subtraction</strong></td>
<td></td>
</tr>
<tr>
<td>- post CE 3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>- 1&lt;sup&gt;st&lt;/sup&gt; – 6&lt;sup&gt;th&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>- post CE 4&lt;sup&gt;th&lt;/sup&gt;</td>
<td>- 2&lt;sup&gt;nd&lt;/sup&gt; – 6&lt;sup&gt;th&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>- post CE 5&lt;sup&gt;th&lt;/sup&gt;</td>
<td><strong>MIP, both</strong></td>
<td><strong>Axial, Sagittal</strong></td>
</tr>
<tr>
<td>- post CE 6&lt;sup&gt;th&lt;/sup&gt;</td>
<td><strong>MPR (2&lt;sup&gt;nd&lt;/sup&gt; post CE) both</strong></td>
<td><strong>Sagittal</strong></td>
</tr>
<tr>
<td><strong>Delayed T1 FS CE (axilla)</strong></td>
<td><strong>T1 with fat saturation</strong></td>
<td><strong>Axial</strong></td>
</tr>
</tbody>
</table>

*Scan time: 25~27 min*
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

ClinicalTrials.gov Identifier: NCT03475979
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.

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

<table>
<thead>
<tr>
<th>No.</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Equipment &amp; Position</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>≥1.5T (Siemens Skyra 3.0T &amp; Philips Ingenia CX 3.0T)</td>
</tr>
<tr>
<td>2</td>
<td>Dedicated bilateral breast coil</td>
</tr>
<tr>
<td>3</td>
<td>Prone position</td>
</tr>
<tr>
<td>4</td>
<td>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</td>
</tr>
<tr>
<td><strong>Image Acquisition</strong>: magnet time ≤10min (9min in both Skyra and Ingenia)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>A localization scan</td>
</tr>
<tr>
<td>2</td>
<td>Axial T2 (with fat saturated)</td>
</tr>
<tr>
<td>3</td>
<td>Axial PreT1 (with fat saturated)</td>
</tr>
<tr>
<td>4</td>
<td>Axial PostT1 (with fat saturated, within 2 min)</td>
</tr>
<tr>
<td>5</td>
<td>Axial Subtraction (PostT1-PreT1)</td>
</tr>
<tr>
<td>6</td>
<td>Axial Subtraction MIP</td>
</tr>
<tr>
<td>7</td>
<td>Sagittal PostT1 MPR</td>
</tr>
<tr>
<td>8</td>
<td>Sagittal Subtraction MIP</td>
</tr>
<tr>
<td></td>
<td>Slice thickness ≤1.5mm (1-1.5mm for T2, 1.0mm for T1); No gap; In-plane resolution ≤1mm</td>
</tr>
<tr>
<td></td>
<td>Derived images</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 REQUIREMENTS:
- High speed internet connection is required (30 Mbps or higher is preferred).
- 17 inch 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

http://www.societyofbreastmri.org/Training.html
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):
\textbf{Fat necrosis vs. Local recurrence}

- Baseline MR

Rim enhancement
± Enhancing internal septation at Op site

<table>
<thead>
<tr>
<th>Thin, regular</th>
<th>Thick, irregular / solid mass(+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iso / lower than fat</td>
<td>Higher than fat</td>
</tr>
</tbody>
</table>

- Benign (Category 2)
- 6 mo FU (Category 3)
- Bx (Category 4/5)

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

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)

Sung UI Shin, et al. 2017 RSNA
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)

ClinicalTrials.gov Identifier: NCT02324894
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
Fused DWI (High b-value DWI with Unenhanced T1WI) and MIP
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.