Developments in Breast Imaging: In Memory of Dr. Carolyn Kimme-Smith
Enhancement Characteristics of Cancer on Breast MRI and Biopsy Techniques

Debra M. Ikeda, M.D.
Director of Breast Imaging
Professor of Radiology
Stanford University, Stanford, CA

Image courtesy of Bruce L. Daniel, M.D.

Open Breast Coil

MRI Devices
4-coil phased array
Patient Positioning

Fibroadenoma

Breast MRI and MRI-Bx

What is actually happening in US clinical practice?

What is breast MRI standard of care?

What are the new BIRADS MRI recommendations for 2010 ACR Atlas?

What are MRI breast biopsy results?
2008 National MRI Trends
Bassett et al. AJR

74% of practices offer MRI (557/754)
62% 5 MRI/wk (n=354), 10% >20/wk (n=54)
  31.7% do no MRI Bx (n=173)
64% do screening MRI (n=359)
All soft copy read, 50% with CAD
48% never/29% rarely read outside MRIs
47% never/38% rarely read MRI w/o mammo/US

Diagnostic Breast MRI Utilization at Stanford

MRI/MRI Biopsy Volumes*

<table>
<thead>
<tr>
<th>Year</th>
<th>MRI</th>
<th>MRI BX</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>335</td>
<td>61</td>
<td>396</td>
</tr>
<tr>
<td>2002</td>
<td>827</td>
<td>105</td>
<td>932</td>
</tr>
<tr>
<td>2003</td>
<td>1120</td>
<td>172</td>
<td>1320</td>
</tr>
<tr>
<td>2004</td>
<td>1150</td>
<td>170</td>
<td>1320</td>
</tr>
<tr>
<td>2005</td>
<td>1120</td>
<td>172</td>
<td>1292</td>
</tr>
<tr>
<td>2006</td>
<td>1231</td>
<td>211</td>
<td>1442</td>
</tr>
</tbody>
</table>

Breast MRI and MRI-Bx
What is breast MRI standard of care?
The Current Status of Breast MR Imaging (Part 1 of 2 parts)

1. Spatial and temporal resolution are important
2. Understand perfusion and capillary leakage, tissue T1 and T2 relaxation
3. Most sensitive for cancer; MRI and Mammo offer complementary information

*Christiane Kuhl, M.D. Radiology 2007, August Vol 244; 2; 356-378

The Current Status of Breast MR Imaging (Part 2)

4. Specificity and PPV for MRI are equivalent to Mammo
5. Work-up for MRI findings are more demanding than mammo or US, improvements for MRI are in great demand
6. Advances have been made in MRI interpretation guidelines
7. MRI biopsy is necessary

*Christiane Kuhl, M.D. Radiology 2007, August Vol 244; 2; 356-378
Screening Reference


MRI Breast Cancer Screening

<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>YEAR</th>
<th>#WOMEN</th>
<th>#CANCERS</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>KUHL</td>
<td>2000</td>
<td>192</td>
<td>HIGH RISK</td>
<td>9</td>
</tr>
<tr>
<td>TILANUS-LINTHORP</td>
<td>2000</td>
<td>109</td>
<td>HIGH RISK</td>
<td>3 (FP)</td>
</tr>
<tr>
<td>WARNER</td>
<td>2001</td>
<td>196</td>
<td>BRCA1/2</td>
<td>7</td>
</tr>
<tr>
<td>STOUTJESDUK</td>
<td>2001</td>
<td>179</td>
<td>HIGH RISK</td>
<td>13 (MRI ONLY)</td>
</tr>
<tr>
<td>MORRIS</td>
<td>2003</td>
<td>367</td>
<td>HIGH RISK</td>
<td>14 (50 FP)</td>
</tr>
<tr>
<td>LEE</td>
<td>2003</td>
<td>182</td>
<td>BRCA1/2</td>
<td>7 (FP)</td>
</tr>
<tr>
<td>HARTMAN</td>
<td>2004</td>
<td>41</td>
<td>HIGH RISK</td>
<td>1</td>
</tr>
<tr>
<td>WARNER</td>
<td>2004</td>
<td>236</td>
<td>BRCA1/2</td>
<td>17/22</td>
</tr>
<tr>
<td>KRIEGE</td>
<td>2004</td>
<td>1909</td>
<td>HIGH RISK</td>
<td>32/45</td>
</tr>
<tr>
<td>LEHMAN</td>
<td>2005</td>
<td>367</td>
<td>HIGH RISK</td>
<td>4 (19FP,5%)</td>
</tr>
</tbody>
</table>

MRI Breast Cancer Opposite Breast

<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>YEAR</th>
<th>#WOMEN</th>
<th>#CANCERS</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIEBEL</td>
<td>1999</td>
<td>17</td>
<td>3 (FP)</td>
<td>11%</td>
</tr>
<tr>
<td>FISCHER</td>
<td>1999</td>
<td>403</td>
<td>19</td>
<td>4%</td>
</tr>
<tr>
<td>KOHL</td>
<td>2000</td>
<td>710</td>
<td>45</td>
<td>6%</td>
</tr>
<tr>
<td>SLANETZ</td>
<td>2002</td>
<td>17</td>
<td>4</td>
<td>24%</td>
</tr>
<tr>
<td>ZIBERMAN</td>
<td>2002</td>
<td>217</td>
<td>12</td>
<td>5%</td>
</tr>
<tr>
<td>LEE</td>
<td>2003</td>
<td>182</td>
<td>7 (FP)</td>
<td>4%</td>
</tr>
<tr>
<td>VIEHWEG</td>
<td>2003</td>
<td>119</td>
<td>4</td>
<td>4%</td>
</tr>
<tr>
<td>LEHMAN</td>
<td>2007</td>
<td>969</td>
<td>30</td>
<td>3.1%</td>
</tr>
</tbody>
</table>
Breast MRI and MRI-Bx

What are the new BIRADS MRI recommendations for 2010 ACR Atlas?

International Working Group for Breast MRI
and American College of Radiology
Breast MRI Lexicon Committee
1998-2003

ACR BI-RADS - MRI
Imaging Atlas, Reston, VA 2003

2006/09 Updates for ACR BI-RADS™

1. Do bilateral studies
2. Describe background enhancement
3. Do T2-weighted non-contrast exams
4. Check Kinetics
5. Facilities doing breast MRI should be able to do MRI-guided biopsy*
6. Do combined reporting
   (MRI Screening advised for 20-25% lifetime risk and women treated for Hodgkin disease**)
*Christiane Kuhl, M.D. Radiology 2007, September Vol 244; 3: 672-691
**Saslow D et al. Ca Cancer J Clin 2007; 57 (2) 75-89

2006 Improvements for ACR BI-RADS™

1. Do bilateral studies**
   Easier to compare symmetry of background enhancement pattern
   Less likely to miss DCIS

**November 2006 BIRADS Committee
RSNA, Chicago, Illinois
C. Non-Mass Like Enhancement

Ductal Enhancement:

DUCTAL enhancement. DCIS.

Courtesy ACR, Illustrated Breast MRI Atlas, BI-RADS-MRI, ACR, Reston, VA 2003
Pure DCIS
MAMMO – 90% CALCS (Ikeda 1988) -10-20% MASS, NODULES
DETECTION RANGES 77-96% (MORRIS 2004)
SIZE, GRADE, ANGIGENESIS, PROTOCOL
14-75% DCIS PROGRESSES TO IDC, 22% RECURRENT (Leonard 2004)
AFTER Rx- 50% recurrences invasive (Bijiker 2004)
Accelerated Partial Breast Irradiation - extent

Pure DCIS
MORPHOLOGY mostly non-masslike, few masses
CLUMPED-cobblestone, occ confluent or HETEROGENEOUS
SEGMENTAL, DUCTAL, LINEAR
REGIONAL – large area, not ductal, random
FOCAL AREA – confined area <25% breast
KINETICS variable- MAY INDICATE HIGH GRADE DCIS IF PRESENT
Raza et al. AJR 2008; 191: 689

DCIS Characteristics
MORPHOLOGY IMPORTANT
SEGMENTAL
DUCTAL ENHANCEMENT
FOCAL AREA
LINEAR
CLUMPED (COBBLESTONE)
PROXIMITY TO IDC
KINETICS LESS IMPORTANT- MAY INDICATE HIGH GRADE DCIS IF PRESENT

Background Enhancement
None/Minimal < 25%
Mild 25-50%
Moderate* 50-75%
Marked* >75%
*Moderate and Marked Background Enhancement can hide invasive or noninvasive cancer
ACR BIRADS Committee. Draft for Breast MRI Lexicon Update, November 2006
Normal Hormone Enhancement Fluctuations

IDC MIP OUTER BREAST-1

IDC MIP OUTER BREAST-2
**Kinetic Description**

- **Initial** slope within 2 minutes or when curve starts to change.
- **Delayed** slope after 2 minutes or after curve starts to change.

**Persist**ent, **plateau**, and **washout** are the key kinetic behaviors observed.

![IDC MIP OUTER BREAST-15](image1)

![IDC MIP OUTER BREAST-16](image2)
Overview:
Contrast-enhanced MRI Protocol at Stanford

- Contrast Curve
- High Res. Dynamic (213 s)
- High Res. Dynamic (6 min 31 s)
- High Res. Dynamic (277 s)
- Curve types, k21, parametric maps
- Morphology ACR MRI Lexicon
- Curve types, k21, parametric maps
Neoadjuvant Chemotherapy

30 patients undergoing neoadjuvant chemotherapy, comparing response and surgical management before/post MRI

16 successful breast conservation

14 mastectomies

MRI would have helped therapy in 6 (20%) 5 mastectomy avoid chemotherapy, 1 would avoid unsuccessful conservation

MRI would hinder therapy in 3: not prevent unsuccessful conservation (1) or prevent successful conservation (3)

Thibault F et al. AJR 2004; 183:1159-68
**T2-weighted images**

- Fluid (cysts) bright against fat
- Normal fluid in ducts
- Lymph nodes (UOQ, vessel, fat)
- Cellular FA (bright, sclerotic dark)
- Lactating patients bright glands, cancers dark
- Breast edema

*Beware mucinous cancers (pitfall)*

---

**Breast CA with High Signal Intensity on T2-weighted Images**

- 30/480 breast cancers had high T2-weighted SI (8 mucinous; 22 nonmucinous cancers) compared 19 FA
- Hi SNR and enhancing septations in mucinous cancers and irregular border, no dark septations and rim enhancement in non-mucinous cancers separated them from FA

---

**What are TP biopsy rates for MRI?**

- Current MRI sequences/hardware make high resolution/kinetic scans now more available
- Several vendors offer CAD, dedicated breast coils, MRI-compatible grids, needles and vacuum assisted biopsy probes
- MRI-guided pre-operative needle localization and vacuum assisted core availability increasing
- Reported TP biopsy rates comparable to mammography

---

**Case 2007- UK4**

- T2 FSE Fat Sat
- T1 3D SPGR Fat Sat - Post Gad
- T1 Spiral 10 seconds after Gd arrival in Breast

Images courtesy of Bruce L. Daniel, M.D.
**Right Breast in Left Coil**

Courtesy Bruce Daniel, MD

**Freehand / Interactive Needle Placement**

MRI Breast Lesion Marking System, E-Z-EM Inc., Westbury, NY

**Vacuum-Assisted Core Needle Biopsy Apparatus**

ATEC MRI Compatible Vacuum Breast Biopsy System  
Suros Surgical Instruments Inc., Indianapolis, IN

**Confirmation on Orthogonal Views**

- Axial Reformat 1.5T 3DSSMT
- Axial 0.5T 3-Pt Dixon SPGR
- Sagittal 0.5T 3-Pt Dixon SPGR

2.8 cm

*MR Safe

Courtesy Bruce Daniel, MD
### MRI-guided Breast Needle Localization Biopsy

<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>YEAR</th>
<th>#WOMEN</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>OREL</td>
<td>1994</td>
<td>10</td>
<td>40%</td>
</tr>
<tr>
<td>FISCHER</td>
<td>1995</td>
<td>15</td>
<td>33%</td>
</tr>
<tr>
<td>KUHL</td>
<td>1997</td>
<td>97</td>
<td>54%</td>
</tr>
<tr>
<td>DANIEL</td>
<td>1998</td>
<td>19</td>
<td>42%</td>
</tr>
<tr>
<td>FISCHER</td>
<td>1998</td>
<td>130</td>
<td>48%</td>
</tr>
<tr>
<td>OREL</td>
<td>1999</td>
<td>137</td>
<td>43%</td>
</tr>
<tr>
<td>MORRIS</td>
<td>2001</td>
<td>115</td>
<td>31%</td>
</tr>
<tr>
<td>LEHMAN</td>
<td>2004</td>
<td>38</td>
<td>40%</td>
</tr>
<tr>
<td>VAN DEN BOSCH</td>
<td>2005</td>
<td>304</td>
<td>34%</td>
</tr>
</tbody>
</table>

### MRI-guided Breast Needle Localization Biopsy

<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>YEAR</th>
<th>#WOMEN</th>
<th>%CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAN DEN BOSCH</td>
<td>2006</td>
<td>304</td>
<td>34%</td>
</tr>
<tr>
<td>VIENWEG</td>
<td>2006</td>
<td>97 LESIONS/63 WOMEN +FH/87 BX (9 IDC/12 DCIS) 10 DISAPPEARED</td>
<td>24%</td>
</tr>
<tr>
<td>CARLSON</td>
<td>2007</td>
<td>85</td>
<td>24%</td>
</tr>
</tbody>
</table>

### MRI-guided Vacuum-Assisted Core Needle Breast Biopsy

<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>YR</th>
<th>#</th>
<th>NOTES</th>
<th>%CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEHMAN</td>
<td>2005</td>
<td>38</td>
<td>AV 36 MIN FOR 1 BX, 59 MIN FOR MULT, BILATERAL 64 MIN</td>
<td>37%</td>
</tr>
<tr>
<td>LIBERMAN</td>
<td>2005</td>
<td>112</td>
<td>14/112 (12%) CANCELLED (GONE), 24/95 (25%) CANCER, 9/95 WERE DISCORDANT (10%), CLIP DEPLOYED IN 66/91 LESIONS</td>
<td>24%</td>
</tr>
<tr>
<td>OREL</td>
<td>2006</td>
<td>85</td>
<td>35 IDC, 17 DCIS, 4 DCIS WAS IDC, 2 ADH WERE DCIS, 2 DISCORDANT (2%) FN</td>
<td>61% (52/85)</td>
</tr>
<tr>
<td>PERLET</td>
<td>2006</td>
<td>538</td>
<td>517/518 SUCCESSFUL, 17 ADH (3%), 362 BENIGN (70%), PPV VARIED DEPENDING ON INDICATION</td>
<td>27% (138/517)</td>
</tr>
<tr>
<td>GIEBAUER</td>
<td>2007</td>
<td>42</td>
<td>42</td>
<td>24% (11/42)</td>
</tr>
</tbody>
</table>

### 2007 Breast MRI and MRI-guided Needle Localization Biopsy

<table>
<thead>
<tr>
<th>FACILITY</th>
<th>#MRI PER YR</th>
<th>TIME TO DO MRI (MIN)</th>
<th># MRI READ PER DAY</th>
<th>#MRI BX PER YR</th>
<th>TIME TO DO BX (MIN)</th>
<th>HOW MANY BX/DAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIDWEST ACADEMIC-K</td>
<td>1500</td>
<td>45</td>
<td>8-20</td>
<td>85</td>
<td>45-60</td>
<td>GRID/VACUU UP TO 2 PER DAY</td>
</tr>
<tr>
<td>MID EAST COAST - P</td>
<td>714</td>
<td>30</td>
<td>6-8</td>
<td>100</td>
<td>40 (60 MIN)</td>
<td>GRID/VACUU 1 AT 6:30 AM</td>
</tr>
<tr>
<td>NORTHWEST -P</td>
<td>2000</td>
<td>30</td>
<td>10 (8-15)</td>
<td>150</td>
<td>60 (60-90 MIN)</td>
<td>GRID/VACUU 60-90 MIN 1,2 SITES</td>
</tr>
<tr>
<td>STANFORD</td>
<td>1225</td>
<td>60</td>
<td>8-25</td>
<td>235</td>
<td>90-120 (2-3 SITES)</td>
<td>FREE-HAND/VACUU 3 PTS/AM MULTIPLE SITES</td>
</tr>
</tbody>
</table>
### 2008 Breast MRI and MRI-guided Needle Localization Biopsy

<table>
<thead>
<tr>
<th>FACILITY</th>
<th>#MRI PER YR</th>
<th>TIME TO DO MRI (MIN)</th>
<th># MRI READING PER DAY</th>
<th>#MRI BX PER YR</th>
<th>TIME TO DO BX (MIN)</th>
<th>HOW MRI BX DONE</th>
<th>HOW MANY MRI BX/DAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>M WEST ACADEMIC</td>
<td>1000</td>
<td>40</td>
<td>3-6</td>
<td>50</td>
<td>90</td>
<td>GRID VACU</td>
<td>1/ DAY AS NEED</td>
</tr>
<tr>
<td>M EAST COAST-B</td>
<td>1200</td>
<td>45</td>
<td>3-8</td>
<td>70</td>
<td>90</td>
<td>GRID VACU</td>
<td>1/DAY 2X/WK</td>
</tr>
<tr>
<td>M EAST COAST-B</td>
<td>1000</td>
<td>60</td>
<td>3-6</td>
<td>100</td>
<td>90</td>
<td>GRID VACU</td>
<td>3-4/1DAY 7-2 PM</td>
</tr>
<tr>
<td>M WEST ACADEMIC</td>
<td>900</td>
<td>60</td>
<td>2</td>
<td>12</td>
<td>90</td>
<td>PILLAR POST VACU</td>
<td>1/DAY SLOTS FOR 2</td>
</tr>
</tbody>
</table>

### Breast MRI and MRI-Bx

- What is actually happening in US clinical practice? – screening, 70% bx
- What is breast MRI standard of care? - bilateral high spatial and temporal resolution
- What are the new BIRADS MRI recommendations for 2010 ACR Atlas? - bilateral scans, T2-weighted, background, kinetics, do bx and combined reporting
- What are MRI breast biopsy results? 30-40% TP for cancer

### Methods: 1.5T Diagnostic MRI

- Axial T1 SE
- Sag Dynamic 3D spiral
- Axial Reformatted 3D SSMT
- Sag Hi-Res Centric 3D SSMT
Thank You!