Case Study | Advanced Apps on Open

OASIS 1.2T: BREAST MRI OPENS ACCESS TO HIGH RISK POPULATION

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There are many tools used today to help assess and diagnose breast cancer and disease through diagnostic imaging including mammography, ultrasound (U/S), Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET), Molecular Breast Imaging (MBI) or Breast Specific Gamma Imaging (BSGI) and digital tomosynthesis. Mammography has long been considered the gold standard for breast cancer screening and detection of non-palpable breast lesions, and is recommended for annual screening in all women beginning at age 40. Mammography is readily accessible, convenient and provides reliable detection of calcifications, but has well-known limitations in diagnosing patients with early stage cancer and those with dense breasts requiring additional imaging, such as U/S or tomosynthesis (3D mammography).

Automated whole breast U/S has gained acceptance as a supplementary screening tool, aimed primarily for low or average risk women and those with dense breasts inadequately visualized with mammography. The modality is widely available, non-invasive and low cost providing additional capability to differentiate between fluid-filled or cystic masses and solid masses including fibroadenomas. Studies show that U/S and mammography used together detect more cancer than mammography alone. However, U/S has limitations imaging deep tissues, imaging the entire breast in one view, and in the detection of calcifications which are often an early sign of breast cancer.

Over the past decade, breast MRI has emerged as a more sensitive modality (85.7% sensitivity compared to 50% for mammography and 42.9% for U/S,) for evaluation of the breast, demonstrating the ability to detect lesions missed on prior imaging studies. The ability to evaluate high risk cancer patients with high sensitivity has made MRI an invaluable adjunctive tool with the common screening methods. Additionally, breast MRI is non-invasive, non-ionizing and gaining in acceptance and accessibility. However, its relatively low specificity has kept breast MRI from becoming an accepted screening tool in the general population.

At Sanford Bismarck we utilize Hitachi Oasis 1.2T Open MRI system for diagnostic and screening breast MRI and MRI guided biopsy procedures. The Oasis design helps our facility overcome the operational challenges associated with MR breast imaging. Studies have shown upwards of 33% of patients referred for breast MRI refused the study, with claustrophobia and high anxiety being the primary reasons. The open design of Oasis helps bring breast MRI to a greater range of patients including claustrophobic, geriatric and bariatric patients and provides great flexibility for interventional device positioning for MRI guided breast biopsy procedures.

A range of imaging sequences including Dynamic Contrast Enhanced MRI (DCE-MRI) and a highly sensitive dedicated breast coil allows for a thorough diagnostic assessment of structural and functional detail. The added flexibility and performance of Oasis allows us to serve patients in a variety of breast evaluation stages including:

- Evaluation of the extent of disease in patients with a new diagnosis of breast cancer
- Contralateral breast screening for patients with new breast malignancy
- Screening high risk patients
- Monitoring response to chemotherapy
- Assessment of breast implant integrity
- Evaluation of known metastatic axillary lymphadenopathy with unknown primary malignancy
- Problem solving for discordant breast imaging or clinical findings

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**Patient History and Diagnostic Procedures**

A 72 year old female presented to our facility for an annual mammography screening exam. The patient had previously been diagnosed with skin cancer (one year prior). More significantly, the patient's sister had been diagnosed with breast cancer at the age of 70, and family history represents a high risk factor for breast cancer.

Our mammographic views included bilateral craniocaudal (CC) and bilateral mediolateral oblique (MLO) and were compared to previous screening mammograms performed one year and up to four years prior. The patient’s left breast showed irregular masses in the medial region, while the right breast showed no masses or abnormalities. Follow-up spot compression mammographic views of the left breast were performed and confirmed irregular masses. The patient was assessed using the Breast Imaging Reporting and Data System (BI-RADS) as a category 0 based on inconclusive screening mammography and spot mammography results, and U/S of the left breast was recommended for further follow-up.

Two weeks later U/S was performed to further evaluate the irregular masses in the left breast. The U/S revealed normal fibroglandular tissue and no masses to correlate with the mammography findings.

Based on discordant mammographic and U/S findings and the suspected multifocal nature of disease, the patient remained a BI-RADS category 0 and MRI breast examination was recommended.
MRI Imaging Technique

Following three inconclusive diagnostic imaging exams, the patient was referred for bilateral breast MRI. The exam was performed on the Hitachi Oasis 1.2T Open MR scanner using a 7 channel bilateral breast receiver coil. Several imaging sequences were acquired (see Table 1) in the axial plane including T1-weighted imaging (T1WI), T2-weighted imaging (T2WI), T2WI with fat saturation, and DCE-MRI (TIGRE). Additionally, sagittal DCE-MRI acquisitions were acquired to provide an additional cross sectional plane for assessing the anatomy. DCE-MRI acquisitions were acquired pre and post contrast administration (10mL Gadavist injection).

A multi-sequence protocol provides many advantages when imaging breasts with MRI. T1WI acquisitions provide morphologic information enabling delineation of fat and glandular structures, while T2WI acquisitions (with and/or without fat saturation) provide bright fluid sensitivity to distinguish abnormalities including cysts and fibroadenomas from background tissue. The most critical acquisitions are DCE-MRI, as they provide the highest temporal and spatial resolution. TIGRE, a gradient echo T1WI fat saturated sequence is acquired pre and post-contrast at different time phases to discern enhancing lesions from normal breast tissues. Additionally, we use time-intensity curves created from DCE-MRI to aid in lesion assessment as malignant cancers tend to have rapid uptake and rapid washout curves.

<table>
<thead>
<tr>
<th>Acquisition</th>
<th>Plane</th>
<th>TR (msec)</th>
<th>TE (msec)</th>
<th>Thick (mm)</th>
<th>FOV (cm)</th>
<th>Matrix</th>
<th>Other Settings</th>
<th>Scan Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE – T1</td>
<td>Axial</td>
<td>430</td>
<td>16</td>
<td>4</td>
<td>36</td>
<td>340 x 268</td>
<td>-</td>
<td>3:54</td>
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<tr>
<td>FSE – T2</td>
<td>Axial</td>
<td>4500</td>
<td>120</td>
<td>4</td>
<td>36</td>
<td>320 x 288</td>
<td>-</td>
<td>4:22</td>
</tr>
<tr>
<td>FSE – T2</td>
<td>Axial</td>
<td>5650</td>
<td>120</td>
<td>4</td>
<td>36</td>
<td>284 x 264</td>
<td>With Fat Saturation</td>
<td>4:20</td>
</tr>
<tr>
<td>3D DCE – T1</td>
<td>Axial</td>
<td>5.7</td>
<td>2.7</td>
<td>3</td>
<td>36</td>
<td>360 x 360</td>
<td>Pre-Gadolinium and Post-Gad performing 6 acquisitions</td>
<td>1:30 per scan (6 scans)</td>
</tr>
<tr>
<td>(TIGRE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3D DCE – T1</td>
<td>Sagittal</td>
<td>5.0</td>
<td>2.0</td>
<td>2</td>
<td>22</td>
<td>224 x 192</td>
<td>Post-Gadolinium</td>
<td>4:05</td>
</tr>
<tr>
<td>(TIGRE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

TR – Repetition time, TE – echo time, FOV – field of view, SE – Spin Echo, FSE – Fast Spin Echo
MRI imaging of the left breast depicted multiple irregular masses with heterogeneous enhancement on TIGRE sequences and mild T2 hyperintensity that correlated with the mammographic findings. MRI of the right breast portrayed multiple masses, the most prominent was located in 9 o’clock position measuring 11mm (fig 3c) with a spiculated appearance and heterogeneous enhancement.

Assessment of the left breast MRI was BI-RADS category 4 meaning there is a suspicious abnormality with a 3-94% chance of malignancy. MRI guided biopsy was recommended. MRI of the right breast was inconclusive (BI-RADS 0) and U/S was recommended to evaluate the right breast mass. Follow up right breast U/S several days later showed a cyst in the 9 o’clock position which was discordant with the MRI findings and MRI guided biopsy was recommended with a BI-RADS 4 final assessment.

Figure 3–Prominent masses visualized using TIGRE (a) left breast and (c) right breast and corresponding T2WI with fat saturation views (b) left breast and (d) right breast. The multiple acquisition approach provides different tissue intensities for lesion characterization.

Figure 4 – Bilateral uniform fat suppressed large FOV imaging allows comparison of (a, b & c) TIGRE pre and post-contrast for excellent lesion delineation. Maximum Intensity Projection (MIP) dynamic subtracted images (d) depict bilateral breast lesions. Drawn Region of Interest (ROI) and corresponding Time Intensity curve (e, f, g & h) enhance the specificity of the lesions, and specifically (g & h) illustrate multi-focal lesions in the left breast. Aegis CAD (Hologic Inc., Bedford, MA) software was utilized.
MR Guided Breast Biopsy Technique

MRI guided breast biopsy is a minimally invasive procedure performed by a specially trained breast radiologist. The radiologist chooses a medial or lateral approach for the procedure based on location of the lesion and for this case a lateral approach was chosen. The patient's breast was compressed between two plates, one assisting with positioning of the breast and the other contains a grid structure which helps localize and guide the biopsy instruments. RF-Spoiled steady-state gradient echo (RSSG) axial and sagittal localizer acquisitions were performed (see Table 2). The 3D RSSG axial view helps visualize the depth of the breast tissue in comparison to the grid device, while the 3D RSSG sagittal view determines location of the lesion. High resolution TIGRE axial pre and post contrast acquisitions were performed for precise localization and positioning of the lesion prior to needle insertion. Post acquisition, using the Oasis MRI system’s software, the radiologist measures the position of the lesion with respect to the grid and calculates the position and depth of the needle placement.

A local anesthetic was used prior to a small nick being made at the site where the introducer sheath, needle probe and subsequently, the biopsy device will be inserted. This was followed by the MRI probe localizer acquisition to verify the probe tip position. This acquisition is repeated as necessary until the sheath is positioned correctly. For this case two attempts were needed.

10 tissue samples were removed from the most prominent left breast mass using the Encor (C.R. Bard Inc.) vacuum assisted core biopsy device at 10-gauge. A vacuum assisted device was chosen to achieve sufficient sampling of the suspicious area and to provide for easy marker clip placement following tissue extraction. Post-biopsy TIGRE images were obtained to ensure appropriate sampling. The marker clip was then placed at the lesion using MRI guidance and 3D RSSG images were obtained to document placement.

Table 2 - Details of Our MR Guided Breast Biopsy Examination as Implemented on a 1.2T Scanner (Hitachi Medical Systems America)

<table>
<thead>
<tr>
<th>Acquisition</th>
<th>Plane</th>
<th>TR (msec)</th>
<th>TE (msec)</th>
<th>Thick (mm)</th>
<th>FOV (cm)</th>
<th>Matrix</th>
<th>Other Settings</th>
<th>Scan Time</th>
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<tbody>
<tr>
<td>3D RSSG</td>
<td>Sagittal</td>
<td>8.5</td>
<td>5.6</td>
<td>3</td>
<td>28</td>
<td>256 x 192</td>
<td>-</td>
<td>1:18</td>
</tr>
<tr>
<td>3D RSSG</td>
<td>Axial</td>
<td>7.5</td>
<td>5.0</td>
<td>3</td>
<td>25</td>
<td>192 x 192</td>
<td>-</td>
<td>1:50</td>
</tr>
<tr>
<td>3D DCE – T1 (TIGRE)</td>
<td>Axial</td>
<td>5.7</td>
<td>2.7</td>
<td>3</td>
<td>36</td>
<td>360 x 360</td>
<td>Pre and Post-Gadolinium performing 4 acquisitions</td>
<td>1:31 per scan (4 scans)</td>
</tr>
</tbody>
</table>

Post Gadolinium Injection

<table>
<thead>
<tr>
<th>Acquisition</th>
<th>Plane</th>
<th>TR (msec)</th>
<th>TE (msec)</th>
<th>Thick (mm)</th>
<th>FOV (cm)</th>
<th>Matrix</th>
<th>Other Settings</th>
<th>Scan Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D – T1 (TIGRE) – Probe Localizer</td>
<td>Axial</td>
<td>4.0</td>
<td>2.0</td>
<td>3</td>
<td>25</td>
<td>192 x 192</td>
<td>Probe Location – Repeated as needed until desired position</td>
<td>1:25</td>
</tr>
<tr>
<td>3D – T1 (TIGRE) – Probe Localizer</td>
<td>Sagittal</td>
<td>5.0</td>
<td>2.0</td>
<td>2</td>
<td>22</td>
<td>224 x 224</td>
<td>Probe Location – Repeated as needed until desired position</td>
<td>1:50</td>
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<tr>
<td>3D RSSG – Marker clip localizer</td>
<td>Axial</td>
<td>7.5</td>
<td>5.0</td>
<td>3</td>
<td>25</td>
<td>192 x 192</td>
<td>-</td>
<td>1:50</td>
</tr>
<tr>
<td>3D RSSG – Marker clip localizer</td>
<td>Sagittal</td>
<td>8.5</td>
<td>5.6</td>
<td>3</td>
<td>28</td>
<td>280 x 280</td>
<td>Optional sequence</td>
<td>1:18</td>
</tr>
</tbody>
</table>
Post-biopsy mammograms were also performed to confirm placement of a marker clip in the breast and to evaluate its placement relative to the target area in the lower, medial breast.

The pathology report confirmed malignancy, specifically intermediate grade ductal carcinoma in situ (DCIS). The left breast final assessment elevated to BI-RADS category 6 (biopsy proven malignancy) and surgical excision was recommended.

The same procedural steps and biopsy device were used on the right breast a week later. Six core samples were taken of the mass. The core samples were sent for pathologic assessment. As with the left breast, mammography was used following the procedure to confirm marker clip placement in the upper, outer right breast. The right breast pathology report confirmed contralateral invasive ductal carcinoma. The right breast final assessment was BI-RADS category 6 and surgical excision was recommended.

After final diagnostic evaluation and review of pathologic reports, the patient underwent a bilateral double total mastectomy procedure. The final bilateral mastectomy specimen pathology showed multiple sites of bilateral invasive ductal carcinoma as well as DCIS. On the day of surgery, the patient had bilateral sentinel node injection procedures performed and surgical axillary lymph node dissections confirmed micrometastasis in one of two left sided nodes and negative lymph nodes on the right side.

### Discussion

In this case, we highlighted how advancements in breast MRI and MRI guided biopsy can improve cancer detection, specifically in those cases where mammography and ultrasound are unable to detect the cancer, and when there is suspected multifocal, multicentric and contralateral disease. Additionally, MRI provides enhanced delineation of the lesion margins and allows for evaluation for any extension, multifocal, multicentric and contralateral disease which is useful for surgical planning.

This particular case detected intermediate grade DCIS and occult invasive ductal carcinoma. DCIS is one of the earliest, noninvasive forms of breast cancer accounting for approximately 20% of all new breast cancers and nearly all invasive breast carcinoma is believed to begin as DCIS. Invasive ductal carcinoma is the most common type of invasive breast cancer and accounts for 80% of all breast cancers.
Earlier studies pointed towards the inability of MRI to detect DCIS. However, the sensitivity for the detection of DCIS has been enhanced through improvements in DCE-MRI acquisitions and other higher resolution imaging sequences. For Sanford Bismarck, the Hitachi Oasis 1.2T Open MRI enables superb image quality for reliable visualization, detection and localization of breast cancer including DCIS compared to 1.5T MRI, while allowing more imaging options for the patient and physician.

The western region of Sanford Health, headquartered in Bismarck, is a non-profit, integrated health system with clinic locations in Bismarck, Dickinson, Jamestown, Mandan and Minot. Sanford Bismarck consists of a 223-bed hospital, four multi-specialty clinics, a college of nursing, seven primary care clinics, three kidney dialysis centers, three occupational health clinics, four walk-in clinics, three long-term care facilities and a comprehensive group of health services in western and central North Dakota. Key accreditations and quality awards include: Joint Commission, American College of Surgeons Level II Emergency and Trauma Center, and Magnet Recognition Program®.

Sanford Bismarck has been granted full accreditation designation by the National Accreditation Program for Breast Centers (NAPBC), a program administered by the American College of Surgeons. Accreditation by the NAPBC is only given to those centers that have voluntarily committed to provide the highest level of quality breast care and that undergo a rigorous evaluation process and review of their performance. Additionally, Sanford Bismarck has received accreditation from the American College of Radiology (ACR) as a Breast Imaging Center of Excellence.

Dr. Christina Tello-Skjerseth, graduated medical school from the University of North Dakota School of Medicine and Health Sciences, in Grand Forks, North Dakota. She completed her residency in radiology at Mayo Clinic, Rochester, Minn.; transitional year — the University of North Dakota School of Medicine and Health Sciences, Fargo. She is certified by the American Board of Radiology. Additionally, she serves as an assistant clinical professor of radiology at the University of North Dakota School of Medicine and Health Sciences.