ACR MRI Accreditation:
Process and Pitfalls

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ACR MRI Accreditation: Process and Pitfalls

I. Evolution of the ACR MRI accreditation program
II. The Qualified Medical Physicist/MR Scientist: Role and Responsibilities
III. Overview of the ACR application process
   - Whole-body MRI
   - Breast MRI
   - Extremity MRI
IV. Common Problems: Phantom and Clinical
V. Expected updates to the ACR Quality Control Manual (2012)

Evolution of MRI Accreditation

- In 1996 the ACR initiated a voluntary whole-body MRI accreditation program utilizing the ACR “Large” phantom for application and QA.
- In 2008, the whole-body program was converted to a modular program with six clinical modules (Head, Spine, MSK, Body, MRA, Cardiac).
- In 2008, the “Small” phantom was introduced for accreditation of special purpose orthopedic scanners. (Note: Is not required for MSK module accreditation on general purpose scanners).
- In 2010, the Breast MRI Accreditation Program was initiated as part of the mammography program and the MRI accreditation program.
- As of January 1, 2012, MRI accreditation became mandatory for non-hospital based imaging facilities receiving Medicare payments.

CMS/MIPPA MRI Accreditation Requirements

As of January 1, 2012, CMS/MIPPA* requires that all non-hospital based facilities providing Advanced Diagnostic Imaging** (ADI) services and receiving Medicare payments for technical components of imaging services must be accredited by one of the CMS-approved accreditation organizations.

- The American College of Radiology (ACR)
- The Intersocietal Accreditation Commission (IAC)
- The Joint Commission (TJC) (Ambulatory Health Care Program)

*CMS: Centers for Medicare and Medicaid Services
MIPPA: Medicare Improvements for Patients and Providers Act
**ADI: MRI, CT and Nuclear Medicine/PET
(Note: ADI specifically excludes: x-ray, ultrasound and fluoroscopy)

Medical Physicist/MR Scientist Responsibilities

- A qualified medical physicist/MR scientist must have the responsibility for overseeing the equipment quality control program and for monitoring performance upon installation and routinely thereafter.
- All facilities applying for accreditation or renewal must demonstrate compliance with the ACR requirements for quality control (QC) by including a copy of the facility’s most recent Annual MRI System Performance Evaluation (must be performed by a medical physicist/MR scientist).
- The annual medical physicist/MR scientist performance evaluation just also include and assessment of the MRI safety program (signage, access control, screening procedures and oxygen safety) as well as an inspection of the physical and mechanical integrity of the system.


Who is the Qualified Medical Physicist/MR Scientist?

- Board certified: ABR, ABMP or CCPM
- Not certified:
  1) Graduate degree in physical science
  2) Two courses in biological sciences and radiation biology
  3) Three (3) years of documented experience in clinical MRI
- Grandfathered:
  Conducted surveys of 3 MRI units between 1/1/2007 and 1/1/2010
- Upon renewal:
  1) Two (2) MRI surveys in prior 24 months
  2) Continuing Education Units (15 CME in prior 36 months)
For non-hospital based facilities, which modalities have been designated by the Centers for Medicare and Medicaid Services (CMS) as “Advanced Diagnostic Imaging” services and thus, must be accredited by 1/1/2012.

1. MRI, CT and Ultrasound
2. MRI, Nuclear Medicine/PET and CT
3. MRI, Ultrasound and Fluoroscopy
4. MRI, Fluoroscopy and CT
5. MRI, Ultrasound and Nuclear Medicine/PET

Reference: Center for Medicare and Medicaid Services website
http://www.cms.gov/Medicare/Provider-and-Certification/MedicareProviderSupEnroll/AdvancedDiagnosticImagingAccreditation.html

ACR Accreditation Application Overview

The accreditation process consists of two phases:

Phase 1: “Entry Application” (Must be completed online.)
Essentially to request a Testing Material Packet for the Full Application

Phase 2: “Full Application”
You will then receive a Testing Material Packet for the Full Application. Please note that within the year (2012), the full application submission will also be available online.

For the whole-body and extremity magnets the Full Application requires:
• Phantom and Clinical Images
• Equipment Performance Report for each magnet (< 1 year) and last quarter QC documents

Note: At the present time the Breast MRI application does not require phantom images but does require the Physicist’s Equipment Performance Report and QC documents.
**Phantom Image Data**

Phantom images must be submitted on DICOM CD-ROM format

CD must contain all five phantom imaging sequences for both large and small phantoms:

1. Sagittal localizer (TE/TR = 20/200 msec)
2. ACR T1-weighted sequence (TE/TR = 20/500 msec)
3. ACR T2-weighted sequence (TE/TR = 20-80/2000 msec)
4. Site T1-weighted sequence and
5. Site T2-weighted sequence

CD should not include an embedded viewer.

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**Phantom Site Scanning Instructions**

Scan #1: ACR Sagittal Localizer
(TE 20/200 ms, FOV = 25 cm, 256x256, slice = 20 mm, NEX = 1, Time = 0.56 s)

Accurate 3D alignment is essential!

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**ACR Phantom Data Forms**

**Large Phantom**

- FOV = 25 cm
- 11 slices: 5mm @ 5 mm gap

**Small Phantom**

- FOV = 12 cm
- 7 slices: 5mm @ 3 mm gap

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**Scan #2: ACR Axial T1**

(Note: Also typically used for weekly QC Measurements.)

- Spin-echo sequence
- TE/TR = 20/500ms
- Slice thickness / gap = 5/5 mm
- 11 slices graphically prescribed from sagittal localizer
- FOV = 25 cm
- Matrix: 256x256
- 1 average (NEX, NSA, etc.)
- Scan time: 2.16 min

Compliments of Ed Jackson, Ph.D.

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**ACR (large) Phantom Analysis**

Scan #3: ACR Axial Dual Echo T2
(TE 20-80/2000 ms, 25 cm, 256x256, multi-slice (11 at 5mm), 1 NEX, Time = 8.56 min)

#1) Slice thickness and position, geometric accuracy, high contrast resolution
#5) Geometric accuracy
#7) Percent image uniformity, ghosting
#8) Low contrast object detectability, and slice position (in #11)

Slide courtesy of E.F. Jackson, Ph.D.
What are the ACR phantom performance guidelines for the percent image uniformity (PIU) and low-contrast detectability (LCD) for 3T and 1.5T systems, respectively?

1. PIU = 87.5% (3T) and 82% (1.5T), and LCD guidelines are the same
2. PIU guidelines are the same, and LCD = 37 (3T) and 9 (1.5T)
3. PIU = 87.5% (3T) and 82% (1.5T), and LCD = 37 (3T) and 9 (1.5T)
4. PIU = 82% (3T) and 87.5% (1.5T), and LCD 37 (3T) and 9 (1.5T)
What are the ACR phantom performance guidelines for the percent image uniformity (PIU) and low-contrast detectability (LCD) for 3T and 1.5T systems, respectively?

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2. PIU guidelines are the same, and LCD = 37(3T) and 9(1.5T)
3. PIU = 87.5% (3T) and 82%(1.5T), and LCD = 37 (3T) and 9 (1.5T)
4. PIU = 82%(3T) and 87.5%(1.5T), and LCD = 37 (3T) and 9 (1.5T)

Reference: ACR website [www.acr.org](http://www.acr.org)

**Common Phantom Image Failures**

1. Poor phantom alignment
   a. Low-contrast detectability (LCD insert miss-alignment)
   b. Slice-thickness (ramps rotated with respect to slice)
   c. Slice-position accuracy (laser alignment or gradient calibration)
2. Ghosting/Artifacts (gradient instability, motion, eddy currents, narrow BW, etc.)
   a. Interference with LCD spokes
   b. RF leaks and others leading to “Unacceptable Artifacts” designation
3. Signal-to-Noise (>1.5T as well as 3T)
   a. Low-field: LCD score < 9
   b. High-field(3T): LCD score < 37
4. Gradient non-linearity (uncorrected)/B₀ inhomogeneity (poor magnet shim)
   a. Geometric distortion
   b. Dimensional accuracy
5. Arrays coil based failures (non-function element or no image intensity correction)
   a. Percent Image Uniformity (PIU) failure
   b. Image intensity correction not used
6. Other:
   Incorrect sequence parameters: FSE vs SE, Half Fourier acceleration (SENSE, GRAPPA, etc), excessive filtering, narrow BW distortions or combined effects

**Poor Phantom Positioning**

- [Image](image1.png)

**Ghosting/Artifacts/Spatial Distortion**

- [Image](image2.png)

**SNR: Low-Contrast Detectability**

- [Image](image3.png)

**No image Intensity Correction: Multi-element Coils (SCIC, CLEAR, PURE, …)**

- [Image](image4.png)
Common Clinical Image Failure

- Unacceptable acquisition parameters
- Each Clinical Module has specific technical requirements.
- The Medical Physicist should review the DICOM header information to confirm appropriate acquisition parameters prior to submission.

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Slice Thickness</th>
<th>Gap</th>
<th>Maximum Post-Processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sagittal</td>
<td>3 mm</td>
<td>2 mm</td>
<td>1.2 mm</td>
</tr>
<tr>
<td>Coronal</td>
<td>3 mm</td>
<td>2 mm</td>
<td>1.2 mm</td>
</tr>
<tr>
<td>Axial</td>
<td>3 mm</td>
<td>2 mm</td>
<td>1.2 mm</td>
</tr>
</tbody>
</table>

At the present time there is no specific ACR MRI phantom.

For Breast MRI Accreditation, the Medical Physicist/MR Scientist has the added responsibility of choosing the phantom to be used for the weekly QA measurements and determining the specifics of the QC program.

Currently, the ACR Breast MRI Accreditation application does not require phantom images.

However because of the specific and detailed requirements for the clinical image acquisition parameters, the Medical Physicist has an important roll in the submission process to confirm that the images meet the technical requirements.

Breast MRI Accreditation Program Requirements

**OVERVIEW**

www.acr.org

Breast Weekly QC Options

- Daily/weekly QC:
  - Choice of phantom and action criteria is up to facility.
  - Decision made by "qualified medical physicist/MR scientist in cooperation with the system vendor".
  - Large ACR phantom in lead coil.
  - Dedicated breast MR systems may use small ACR phantom in breast coil.
  - Other vendor-supplied phantom.

The Medical Physicist will need to review the DICOM header information for the site to confirm that the images meet the ACR guidelines, e.g. slice thickness, phase and frequency-encoding steps, FOV and image acquisition time.

Common Clinical Image Problems in Breast MRI Accreditation:

1. Incorrect acquisitions parameters (pixel > 1 mm, slice > 3 mm or gaps > 0 mm)
2. Poor fat suppression or no pre-post contrast subtraction images
3. Interpolated images
4. Poor Position of breast within coil (skin folds)
5. Artifacts from truncation, wrap (slice and phase), motion,
In regard to ACR Breast MRI accreditation, only one of the following is correct?

- The MRI system must be a dedicated breast facility
- Routine QA does not require the use of a phantom
- The MRI field strength must be at least 1.5T
- No phantom images are required as part of the accreditation application
- The use of a bilateral coil is optional

Reference: ACR website [www.acr.org](http://www.acr.org)

### Anticipated Changes in the ACR MRI Quality Control Manual
(Revision expected 2012)

(Note: Changes have yet to be approved)

1. Annual Physics Report must include verification of technologist weekly QC measurements (i.e. repeated weekly QA at annual visit)
2. Annual Physics Report must include evaluation of all pulse sequences required for accreditation submission
3. Revised method for slice-thickness calculation w/background correction
4. Description of additional methods for field uniformity assessment
   - Spectral Peak
   - Phase Angle Difference
   - Phase Map
   - Bandwidth-Difference
5. Improved description of slice-position accuracy guidelines
6. Removal of slice cross-talk requirement
7. Recommends NEMA methods for SNR, PIU and PSG
8. Required review of site safety policy

Medical Physics Annual Performance Report Clarification
1. Must have some form of field uniformity assessment
2. Must have monitor assessment

### ACR Annual Performance Report Measurements, ct'd

1. Magnetic field uniformity
2. Slice Position Accuracy
3. Slice Thickness Accuracy
4. RF Coil Checks
   - Volume Coils
     - Signal-to-Noise Ratio (SNR)
     - Percent Image Uniformity (PIU)
     - Percent Signal Ghosting (PSG)
   - Surface Coils (Coil arrays)
     - Maximum SNR
5. Soft Copy (Monitor) Display
   - Max and Min Luminance
   - Luminance Uniformity
   - SMTE pattern evaluation

### Annual Site Safety Review (Proposed 2012 ACR Manual)

At the time of the annual performance testing, the qualified medical physicist/MRI scientist should review the site’s written safety policies, determine that the written policies are readily accessible to facility staff, and make recommendations for improvement. The categories listed below should be included in the review.

MR Safety Policies and Procedures Checklist
- Site Access Restrictions (MRI Zones)
- Documentation of MRI Safety Education/Training for all personnel
- Patient and staff MRI Precedence Counseling
- Pediatric Patient Policy
- Concomitant MRI Safety Officer
- Vendor Policy
- General Policy
- Jaundice Policy
- Acoustic Noise Policy
- Radioactive Tracer Policy
- Contrast Agent Safety Policy
- Sedation Policy
- Thermal Burns Policy
- Emergency Code Procedures
- Equipment and/or destruction of MRI Safe/Conditional status
- Procedures for Reporting MRI Safety Incidents or Adverse Incidents
- Patient Communication
- Infection Control

Criteria for Compliance
1. Written policies are present and are being reviewed and updated on a regular basis.
2. Facility has appropriate signage and methods of controlled access.
   Documentation of regular MRI safety training for each facility staff member

### Magnetic Field Uniformity: (Proposed 2012 ACR Manual)
Phase Map Method

GE Sequence: TE = 1/resonance frequency (ppm) (e.g. 1.5T = 1/63 Hz = 15.6 ms)

- TE = 10 ms ~ 0.8 ppm/transition
- TE = 20 ms ~ 0.4 ppm/transition
SNR Image-Difference Method
(Proposed 2012 ACR Manual)

\[
\text{SNR} = \frac{\text{Mean Signal}}{\sqrt{2} \text{ std}}
\]

\(\sqrt{2}\) corrects for error propagation.


\*NEMA MS 1-2008: Determination of Signal-to-Noise Ratio in Diagnostic Magnetic Resonance Images (Method 1)

Comments

• The quality of your contributions to the accreditation process will often determine if the site passes or fails.

• However of considerably higher importance, is that your contributions can often determine if the site is providing the best possible clinical results.

Final Comment

Please remember: The ACR Accreditation Review will be delayed until all required medical physics documents are included in the submitted documents.
Revised Wording for Annual System Performance Evaluation

1. Repeat and Verify Weekly QC Measurements:
   - Setup and positioning accuracy (mechanical inspection)
   - Central frequency
   - Transmitter gain or attenuation (head coil RF calibration)
   - Geometric accuracy (gradient calibration)
   - High contrast spatial resolution
   - Low contrast detectability
   - Image artifact assessment
   - Hard copy (film) QC
   - Soft copy (Monitor) QC
   - Visual checklist

2. Perform the scans required for accreditation submission and evaluate per the criteria in the MRI Accreditation Phantom Guidance Document