ACR MRI Accreditation Program: The Technologist’s Role

Geoffrey D. Clarke, Ph.D.
University of Texas Health Science Center at San Antonio
Radiological Sciences Division

Overview

- ACR MRI Accreditation Program
  - Application process & staff requirements
- ACR MRI QC Phantom
- Clinical Imaging
  - Head, cervical, lumbar & knee
- ACR MRI QC Manual
- Technologist's Responsibilities for QC

ACR MRI Accreditation Program Overview

- Voluntary & Educational in Nature
- Evaluates qualifications of personnel
- Evaluates equipment performance
- Evaluates effectiveness of quality control measures
- Evaluates quality of clinical images
Two-Part Application Process

• Review of the entry application
  – Credentials of physicians, physicists/MR scientists, and technologists
  – Information common to the practice of MRI

• Acquisition of clinical and phantom images
  – Required clinical images consist of routine brain, cervical spine, lumbar spine, and knee
  – Must use a designated MRI phantom
  – Data must be obtained from each full body general purpose magnet at the site

• Appeal process if failure

Technologist Requirements

Technologists performing MRI should:
1. Be certified by ARRT as a MR Technologist, OR
2. Be certified by ARRT and/or state licensure and have 6 months of clinical MRI experience, OR
3. Have an associates degree in an allied health field or a bachelors degree and certification in another clinical imaging field and have 6 months supervised clinical MRI experience

Clinical Images - Acquisition

1. Routine Brain examination (for headache)
   • Sagittal short TR/short TE with dark CSF
   • Axial or coronal long TR/short TE (or FLAIR) and long TR/long TE (e.g., long TR double echo)

2. Routine Cervical Spine (for radiculopathy)
   • Sagittal short TR/short TE with dark CSF
   • Sagittal long TR/long TE or T2*W with bright CSF
   • Axial long TR/long TE or T2*W with bright CSF
Clinical Images - Acquisition

3. Routine Lumbar Spine (for back pain)
   • Sagittal short TR/short TE with dark CSF
   • Sagittal long TR/long TE or T2*W with bright CSF
   • Axial short TR/short TE with dark CSF and/or long TR/long TE with bright CSF

4. Complete Routine Knee examination (for internal derangement)
   • To include sagittal(s) and coronal(s) with at least one sequence with bright fluid

Clinical Images - Evaluation

Each set of clinical images will be evaluated for:
• Pulse sequences and image contrast.
• Filming technique.
• Anatomic coverage and imaging planes.
• Spatial resolution.
• Artifacts.
• Exam ID - All patient information annotated on clinical exams will be kept confidential by the ACR.

Clinical Images - Resolution

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Slice Thickness</th>
<th>Gap</th>
<th>Maximum Pixel Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Brain</td>
<td>≤ 5 mm</td>
<td>≤ 2 mm</td>
<td>≤1.2 mm</td>
</tr>
<tr>
<td>C-spine Sagittal</td>
<td>≤ 3 mm</td>
<td>≤1 mm</td>
<td>≤1 mm</td>
</tr>
<tr>
<td>C-spine Axial</td>
<td>≤ 3 mm</td>
<td>≤1 mm</td>
<td>≤1 mm</td>
</tr>
<tr>
<td>L-spine Sagittal</td>
<td>≤ 5 mm</td>
<td>≤1.5 mm</td>
<td>≤1.5 mm</td>
</tr>
<tr>
<td>L-spine Axial</td>
<td>≤4 mm</td>
<td>≤1 mm</td>
<td>≤1.5 mm</td>
</tr>
<tr>
<td>Knee</td>
<td>≤4 mm</td>
<td>≤1 mm</td>
<td>≤0.75 mm</td>
</tr>
</tbody>
</table>
ACR Phantom Goals

- Tests run in a short time
- Pulse sequences as compatible as possible with all commercial MRI scanners
- Specific measurements to account for:
  - Geometric Distortion
  - Slice Thickness & Position
  - Factors Affecting Image SNR (resolution, bandwidth, ghosting)
  - Image Uniformity
- Affordable ($730)
- Results easily evaluated

Documents for Using Phantom

How to scan...

How to analyze...

$25 per set from ACR

ACR MRI Accreditation Program

MRI Survey Agreement

- Official request for ACR Accreditation
- Site agrees to provide all documentation, including but not limited to quality control logs, films, records, or any necessary information requested by the survey team
- Agree to use the ACR MRI phantom
Technologist Responsibilities

- Designated and trained QC Technologist(s)
- Maintain QC Notebook
  - QC policies and procedures
  - data forms where QC test results are recorded
  - notes on QC problems and corrective actions
- Review QC Data with QA Committee
- Only Use Alternative Phantoms & Procedures when documented by physicist or MRI Scientist
- Follow Action Limits Established by Physicist or MRI Scientist

Technologist's QC Tasks

- Perform image quality tests as appropriate (at least weekly):
  - Central Frequency
  - Signal-to-noise ratio Image Quality
    - High contrast resolution
    - Low contrast detectability
  - Image Artifacts
- Perform weekly checks of hard copy fidelity (processor sensitometry)
- Weekly visual inspection of equipment
**Setting Up Routine Image QC**

- Daily (weekly) tests
- Develop cheat sheets to speed process
- System for rapid positioning of phantom

TO SET ACTION LIMITS: Review data after first ten days to establish baseline values and variability.

**Time to Perform QC**

- Set-up Phantom: 2 minutes
- Center Frequency: 1 minute
- Table Positioning: 1 minute
- Setup & Scanning: 3 minutes
- Geometric Accuracy: 5 minutes*
- High Contrast Resolution: 2 minutes*
- Low Contrast Resolution: 1 minute
- Artifact Analysis: 1 minute
- Film Quality Control: 10 minutes
- Visual Checklist: 5 minutes

* Geometric accuracy analysis on sagittal is done while scanning axial

**Central Frequency & Transmitter Gain**

- Record center frequency value on ACR phantom or manufacturer’s phantom
- Reflects power required to optimize RF pulse:
  - Depends on coil, phantom, pulse sequence, etc.
  - Should remain constant over time if nothing in pulse sequence or hardware has changed
Transmitter Gain Terminology Varies

- **GE**: displayed on screen (dB)
- **Philips**: under system performance parameters
  - rf_act_drivescale
- **Siemens**: “options” – “adjustments”
  - Frequency
  - Transmitter amplitude (temp) (V)
- **Toshiba**: “acquisition window”
  - Center frequency (MHz)
  - RF level

Geometric Accuracy

- Measure distance along main axes of phantom
- Compare with known values

Geometric Accuracy - Axial

Failure Due To:
- Miscalibrated Gradients
- Low Receiver Bandwidth
- High $B_0$ Inhomogeneities
Percent Geometric Distortion

T1-Weighted, Central Slice

Date of Measurement:

- System #1
- System #2
- System #3

Assessment of MR Image Quality

- Using ACR Phantom
- High Contrast Resolution
- Low Contrast Detectability (also used for SNR)

High Contrast Spatial Resolution

- Evaluate visibility of holes arranged in two square arrays
- Avoid partial-volume artifact from tilting.
High Contrast Resolution

• Specific but not sensitive
• Action Criteria:
  • Any reduction in # of holes seen
• Suggestive of:
  • Increased eddy currents
  • Poor gradient calibration
  • Poor $B_0$ uniformity
  • Reduced stability of system

Low Contrast Detectability

• Four sets of plastic membranes with holes 1.5 mm to 7 mm in diameter
• Only look at one slice:
  - determined by Physicist/MR Scientist

Low Contrast Detectability

1.5 T System: T1-Weighted Scan

- 1.4% contrast
- 2.4% contrast
- 3.7% contrast
- 5.1% contrast

Date

Hole Size Visualized (mm)


Hole Size Visualized (mm)
Low Contrast Detectability

ACR Slice #8 (1.4% Contrast)

Measurement of System SNR

- Can be performed by technologist
- Method to be used
  - Manufacturer’s method
  - ACR method
- Automated analysis and recording often available on modern MRI systems

LCD and Signal-to-Noise
Artifact Evaluation

- Check for:
  - Distortion?
  - Ghosts in phantom or background?
  - Streaks?
  - Bright or dark spots?
  - New features?

Artifacts

- Good Scan
- Spike
- Drop Out
- DC Offset

ACR MRI Standard
Hardcopy Image QC Tests

- Sensitometric Measurements for Film Processors
- Hard Copy of SMPTE test pattern
- Similar to process used for mammography program
- Laser camera film less sensitive to temperature changes
**Laser Film QC**

Weekly:
- View SMPTE pattern
- Verify gray levels
  - 0/5% & 95/100% patches
- Film 6 on 1
  - 4 on 1 if necessary
- Plot OD of
  - 10%, 40% & 90% patches
- Observe film for artifacts

**Action Limits**

<table>
<thead>
<tr>
<th>SMPTE patch</th>
<th>OD</th>
<th>Control Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2.45</td>
<td>±0.15</td>
</tr>
<tr>
<td>10%</td>
<td>2.10</td>
<td>±0.15</td>
</tr>
<tr>
<td>40%</td>
<td>1.15</td>
<td>±0.15</td>
</tr>
<tr>
<td>90%</td>
<td>0.30</td>
<td>±0.08</td>
</tr>
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**Quality Control Program Records**

- Data form for daily (weekly) equipment quality control
  - ACR MRI QC manual, pg. 64
- MRI Facility quality control visual checklist
  - ACR MRI QC manual, pg. 65
- Laser film printer control chart
  - ACR MRI QC manual, pg. 66
If QC Test Fails….

- Common errors-
  - Check for magnetic objects in bore
  - Check connections and reseat head coil
  - Reposition & landmark phantom
  - Make sure scan room door securely closed

- Repeat QC scan procedures
- Record results again in QC notebook

Successful MRI QC Program

1. Technologists run QC scans on a daily basis
2. Set action criteria – repeat QC procedure
3. Physicist reviews QC data quarterly or semiannually
4. Record data - report problems to service
5. Have service record problems and solutions in a service log