ACR MRI
Accreditation Program:
The Technologist’s Role

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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…

Site Scanning Instructions for Use of the MR Phantom for the MRI Accreditation Program

How to analyze…

Phantom Test Guidance for the ACR MRI Accreditation Program

$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
ACR Magnetic Resonance Imaging Quality Control Manual 2001

$57.50 from ACR
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
- Center Frequency
- Table Positioning
- Setup & Scanning
- Geometric Accuracy
- High Contrast Resolution
- Low Contrast Resolution
- Artifact Analysis
- Film Quality Control
- Visual Checklist

- 2 minutes
- 1 minute
- 3 minutes
- 5 minutes*
- 2 minutes*
- 1 minute
- 1 minute
- 1 minutes
- 10 minutes
- 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

Poor Gradient Calibration
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

1.4% Contrast Detectability 2.4% Contrast Detectability

Slice #8 Slice #9
Low Contrast Detectability
1.5 T System: T1-Weighted Scan

![Graph showing hole size visualized (mm) vs date for different contrast levels (1.4%, 2.4%, 3.7%, 5.1%) over a period from 1-May to 26-Apr. Graph includes different line styles for each contrast level.](image-url)
Low Contrast Detectability

ACR Slice #8 (1.4% Contrast)

Date

Number of Hole Sets

System #1
System #2
System #3

System #3 Grad Amp Bad
Another New Gradient Amp
Mini Upgrade
Bad Slice Positioning
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?

Ghosting in phantom
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>
</tbody>
</table>
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