

MRI Accreditation Program Clinical Image Quality Guide



Introduction

Read this entire document carefully. This document provides guidance for interpreting physicians and technologists on the criteria evaluated by reviewers for the ACR MRI accreditation program. Although all interpreting physicians performing MRI must assume responsibility for the quality of images produced by the facility, the primary responsibility for image quality and for implementing an effective QA program belongs to the lead interpreting physician. The lead interpreting physician must understand the program and demonstrate an interest in the results. Successful facilities are often those where the staff's commitment to high quality is a reflection of the interests of the lead interpreting physician. Criteria for quality image evaluation are continual and should be critiqued on a routine basis.

Some of the examinations are considered "specialty" examinations, and these are marked with an asterisk (*) in the Examination Specific Parameters section of this document.

Prior to submission of any images for evaluation, the interpreting physicians and technologists at your facility **must** review the accreditation criteria contained in this document. **Note: Although some aspects of MRI examinations are requirements for accreditation, other aspects in this document are only intended as a guide, and the technique parameters mentioned in this document are only suggestions unless otherwise stated.**

Basic Assumptions

It is presumed that the images submitted by the site are the best available. The site should take sufficient interest in the accreditation process to have the submitted films selected by a physician who is knowledgeable about image quality. As a practical matter, the ACR recognizes that in some cases images may be of adequate diagnostic-quality but are less than optimal.

Every unit must apply for all modules routinely performed on that unit for a facility to be accredited.

The pulse sequences that are used clinically for examinations of different body regions are variable due to personal preferences of the users as well as due to the capabilities of the different MRI systems. Despite this variability, experienced interpreting physicians are able to agree on what constitutes "acceptable" and "unacceptable" diagnostic exams based on both objective and subjective criteria. The intention of accreditation is to provide guidelines on what constitutes optimal image quality above that which is normally acceptable and to promote the best practice at all times.

Sites cannot submit examinations performed on models or volunteers. The images submitted for each individual exam must be from the same patient (i.e., all brain images must be from the same brain study), with the following exception: facilities submitting only one examination for the cardiac module may submit the Black Blood and Delayed Enhanced Cine sequences from two different patients.

Submit normal or near normal examinations if possible. The submitted examinations should demonstrate as little pathology as possible. **Note: The purpose of the accreditation evaluation is to review the quality of the practice of MRI at applicant facilities and not to comment on abnormal findings. The ACR is not responsible for clinical findings shown on the films. Submitting abnormal examinations may significantly delay the accreditation process.**

MRI Evaluation Categories

The categories for scoring examinations submitted for ACR MRI Accreditation are:

- A. Pulse Sequences and Image Contrast
- B. Filming Technique (for hard copy film submissions only)
- C. Anatomic Coverage and Imaging Planes
- D. Spatial and Temporal Resolution
- E. Artifacts
- F. Exam Identification: Missing Information

Criteria within each category that apply to all examinations are listed first in this document. Categories B, E and F do not have examination specific criteria. Descriptions of evaluation criteria specific to A: Pulse Sequences and Image Contrast, C: Anatomic Coverage and D: Spatial and Temporal Resolution for each examination follows in the Examination Specific Parameters tables starting on page 9 of this document.

Category A: Pulse sequences and image contrast:

The type of pulse sequence (i.e. conventional SE, multishot RARE or gradient echo) and the precise imaging parameters (i.e. TR, TE, FA, ETL, etc) are not specified and are left to the discretion of the imaging facility **unless otherwise stated**.

Warning: The total acquisition time for all required sequences must be equal to or less than this maximum acquisition time, or the examination will fail.

Maximum examination times are listed for all examinations and are calculated by summing the acquisition times for all REQUIRED sequences.

Submit complete examinations. Not all of your sequences may be scored. The Examination Specific Parameters section of this document lists the sequences considered to be the minimum necessary for a quality examination.

Warning: If any of these sequences is not submitted, the examination will fail.

If your facility performs more sequences than the required minimum, you should still submit these additional sequences also. **You must submit localizer or scout sequences with cross-reference locations for each clinical examination.**

All sequences must demonstrate sufficient Signal to Noise (SNR), and not appear too grainy.

If contrast is required, it is very important that patient selection is appropriate for the examination using contrast. Please refer to the ACR Quality and Patient Safety web page for more information on IV contrast safety at:

http://www.acr.org/SecondaryMainMenuCategories/quality_safety.aspx

Category B: Filming Technique: (Hard copy submission only)

Filming Technique

- Images must be photographed large enough to be evaluated.
- Films must be formatted at no more than 20 on 1 for a 14 x 17 film.
- Each image should be numbered sequentially and photographed in anatomic order.
- The films may also be numbered sequentially with a grease pencil or stick-on label, but this is not a requirement.
- There should be no missing images or images photographed out of numerical sequence.
- If applicable, non-contrast scans should be photographed in sequence separate from contrast-enhanced scans.
- Delayed scans should also be photographed in a separate series in anatomic order.
- The overall film density should be appropriate to display anatomic structures.
- Gaps in the alphanumeric information may suggest that the density is set too low, while loss of definition or blooming may suggest density is set too high.
- The film should not exhibit variation in density across the film or between individual films.
- There should be no areas of the film where the images or alphanumerics appear blurry.
- The digital scout radiograph should be displayed either as an image the same size as the axial images or in a larger format and must show the cross-reference locations.
- It may be on the same film as the axial images or on a separate film. The scan locations (as indicated by an image number or location) should be displayed on the scout radiograph.

The major components of filming technique that will be evaluated are; (1) perceived contrast, (2) format and image size, and (3) film fog and (4) density.

Filming techniques can significantly impact perceived contrast. Unlike CT, where window level and width can be standardized for different studies based on the reproducibility of Hounsfield Units (e.g. "bone windows" or "liver windows"), standardization of filming techniques for MRI is more problematic. Intensity values are variable according to patient, sequence, and machine. It is difficult to specify ideal window levels and widths for each body part. Brightness and image contrast reflect the personal preferences of the interpreting physician and technologist. How an image is filmed can have a dramatic effect upon the diagnostic value of an MR study. Images that are filmed with too much contrast may hide some types of pathology (e.g. subtle contusions in the bone marrow) and exaggerate others (e.g. meniscal tears in the knee) Darkening the image background may provide a more aesthetically pleasing image by eliminating background noise artifact, but it can obscure important diagnostic information.

Category C: Anatomic coverage and imaging planes:

Proper anatomic coverage and imaging planes are important components of clinical MRI exams. The minimum sets of images required for each examination and the anatomy to be included on those images are listed in the Examination Specific Parameter section.

Warning: Failure to meet minimum coverage specifications outlined in this document will result in failure for that examination.

Category D: Spatial/Temporal Resolution

The **spatial resolution** necessary for quality MRI images varies by examination and sequence. MRI facilities must use the determinants and formulas listed below to determine the spatial resolution of their clinical MRI examinations.

The five determinants of pixel/voxel dimensions in an MRI examination are listed below:

1. Slice thickness (ST)
2. Field of view along the phase encode direction (FOVp)
3. Field of view along the frequency encode direction (FOVf)
4. Number of phase encoding steps (Np) (This is your phase matrix)
5. Number of frequency encoding steps (Nf) (This is your frequency or read matrix)

Your images will be scored on *acquisition* parameters, not *interpolated* parameters. Use the pixel/voxel dimensions from your scan protocols and the formulas below to calculate your in plane pixel size in both the phase and frequency directions for all of the sequences you are submitting for accreditation review (see Examination Specific Parameters section below for list of required sequences) and record those values on a piece of paper. Compare those values to the values listed in the Examination Specific Parameters section of this document.

Note: If you are using a rectangular field of view, your phase FOV will be different from your frequency FOV. This may also be true for your matrix. If you are not sure, consult your manufacturer.

To determine the pixel size in the phase direction, use this formula: $FOVp/Np$

The field of view in the phase encoding direction divided by the number of steps in the phase encoding direction equals the pixel size in the phase encoding direction.

To determine the pixel size in the read or frequency direction, use this formula: $FOVf/Nf$

The field of view in the frequency encoding direction divided by the number of steps in the frequency encoding direction equals the pixel size in the frequency direction.

To determine the pixel area (use this for 2D sequences), use this formula: the pixel size in the read or frequency direction times the pixel size in the phase direction equals the pixel area.

To determine the voxel volume (use this for 3D sequences), use this formula: the pixel size in the read or frequency direction times the pixel size in the phase direction times the slice thickness.

The determinants of **temporal resolution** are:

1. Speed of frames per millisecond
2. Temporal resolution = msec/frames
3. For cine images, the number of views per segment (nvs) or segmentation factor also controls acquired temporal resolution.

Note that most manufacturers use phase sharing (view sharing techniques) to increase the visual smoothness of the cine movies. The parameters in the Examination Specific Parameters refer to temporal resolution *before* these view sharing techniques.

With view sharing, images that are acquired every 80 msec can be interpolated, so that the cine display shows a new image every 40 msec (or less). However, each image still contains 80 msec worth of data.

To determine the temporal resolution, use this formula:

$$\text{Temporal resolution (cine)} = \text{TR} \times \text{NVS}$$

Where NVS is the number of views per segment, or segmentation factor and TR is the intrinsic or minimum TR of the pulse sequence. Some manufacturers may not display this TR value. If in doubt, please contact your manufacturer's application specialist.

Category E: Image Artifacts

Artifacts on any image may interfere with image interpretation. Although some artifacts may be unavoidable on certain images (e.g. susceptibility artifacts near sinuses on T2 weighted brains); others may be indicators of inadequate equipment or lack of preventive maintenance at an MRI facility.

The artifacts listed are among the most common. All of the images should be assessed to determine if any of these artifacts are present and especially if they could potentially compromise the diagnostic value of the images. Your examinations will be reviewed for **excessive** artifacts that may interfere with image quality.

1. Aliasing: The image appears wrapped around into itself. This is due to a large body portion included in a too small FOV.
2. Truncation artifacts (Edge ringing): Periodic parallel lines or ringing adjacent to borders or tissue discontinuity, in either the phase and/or frequency encoding directions. This is due to a small matrix.
3. Black Boundary (India ink): Well-defined black contours outlining regions of MR anatomy, without corresponding anatomical structure.
4. Heterogeneous brightness (Shading): This is due to RF heterogeneity, improper patient positioning, or metal in the magnet or on the patient.
5. Heterogeneous fat suppression: uneven darkening of the fat signal in different portions of the image set. This may be due to either a heterogeneous magnetic field or a heterogeneous RF field.

6. Susceptibility: Localized field distortion or non-uniformities produced by differing tissue magnetic susceptibility (especially at air-tissue interfaces).
7. Chemical shift: Occurs along the frequency encoding axis at fat/water soft tissue interfaces as a thin intense band of high signal or low signal.
8. Ghosting: Periodic replication of partial copies of images of the original structure along the phase encoding axis due to motion. It includes artifacts from swallowing (C-spine), respiration and peristalsis (L-spine), CSF pulsation (brain and spine), vascular pulsation (brain and knee) and cardiac motion (T-spine)
9. Geometric distortion: Size, orientation or shape is not accurately represented on the image.
10. Excessive filtering: Excessive smoothing using software to reduce apparent noise in the image. Excessive filtering or smoothing obscures true anatomical structure and/or contrast.
11. Misregistration of 2D images: Consecutive 2D images do not line up so some anatomy is skipped and other regions are imaged twice. This can also be a particularly serious problem on 2D time-of-flight MRA MIPs.
12. Misregistration of subtracted images: On subtracted images, there is incomplete subtraction of the background tissue signal with prominent signal at edges that do not align properly.
13. Ringing: Accentuation of edges due to either under sampling of k-space (not enough phase encoding steps) or at the leading edge of the bolus on an enhanced 3D MRA study due to IV contrast being present during acquisition of peripheral k-space but not as much during acquisition of the center of k-space.
14. Stair step (Venetian blind artifact): In MRA, a vessel goes obliquely through slices, due to slice thickness and vessel size. Venetian blind occurs on multi slab MRA (typically on reformations and MIPs), when the adjacent slabs are not properly and seamlessly overlapped.
15. Reformatting artifacts: Improper MIP and reformations may give the false appearance of vessel occlusion or stenosis when it is only partially included in the MIP volume. Superimposed vessels may falsely appear stenotic on MIP due to stealing of voxels at the vessel edges. Stair step artifact may occur on oblique reconstruction when the slices are too thick or there is insufficient zero filling.
16. ECG lead artifacts: The ECG leads used for cardiac gating should not produce excessive artifacts that would interfere with the interpretation of the image.
17. RF leak or "zipper" artifact: Linear hyperintensity parallel to the phase encoding direction often caused by unwanted sources of RF signals originating within (e.g., light bulb failure) or outside (e.g. inadequate RF shielding) the scanner room.
18. Echo train blurring: Image blurring due to excessively long echo spacing and/or echo train length.
19. Other: There are other artifacts that are not as common as those listed above but which may be important.

Category F: Exam Identification

All labels should be easily readable and placed so as to not overlap with the relevant anatomy on the image.

Film submission: The following exam information should be printed on films. If all of the information is not available on the filmed images, you must include a screen print or demographics page on the films you submit. If there are images from more than one pulse sequence on a single sheet of film, the sequence used to obtain each image should be easily identifiable.

Electronic submission: If you are submitting your images electronically, the information should be on the images, or **readily assessable** by the reviewer.

Warning: If the parameters listed below in Bold and Italics are not available to the reviewer, that examination will fail.

1. Each sheet

- Patient name (First and last) (Note: All patient information annotated on clinical examinations will be kept confidential by the ACR, as stated in the *Practice Site Survey Agreement*.)
- Patient age or date of birth
- Patient identification number
- Date of examination
- Study number

2. Each sequence on each sheet of film

- Type of sequence
- TR
- TE
- TI (if applicable)
- Flip angle
- ***Slice thickness***
- Trigger delay (if applicable)
- ***Interslice gap (can be inferred from slice position)***
- ***Field of view***
- ***Acquired matrix*** (number of frequency encoding steps and number of phase encoding steps – interpolation or other post acquisition enhancements should not be taken into consideration)
- Acquisition time (indicated or easily calculated)
- Size scale e.g. scored lines indicating centimeters. ***(If this information is missing from hard film submission, that examination will fail.)***
- Number of excitations
- Plan scan or scout identifying the location of each sagittal or axial slices. The location of the “plan scan” should be readable and easily related to the diagnostic images. ***(If this information is missing on spine examinations, that examination will fail.)***

3. Each image

- Location
- ***Laterality (left or right, e.g. knee), left or right of midline (e.g., brain and spine studies)***
- ***Label that indicate location of slice relative to other slices***
- ***Number that correlates with “plan scan” or scout identifying the location for each slice***

4. Each exam

- Facility name and address

5. The following labels are not required but are strongly recommended for each sequence.

- Echo train length
- Bandwidth
- Initials or name of technologists who performed the exam

Examination Specific Parameters

IAC/Temporal Bones for hearing loss– maximum examination time ≤ 30 min			
Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
Axial or coronal high resolution dark fluid (Without fat suppression)	Must have good discrimination of the 7 th and 8 th cranial nerves.	Must cover top of IACs to cervico-medullary junction	Slice Thickness ≤ 3 mm Gap ≤ 0.2 mm In Plane pixel (read) ≤ 0.7 mm In plane pixel (phase) ≤ 0.9 mm Pixel Area ≤ 0.6 mm ²
Axial or coronal high resolution bright fluid	Must have good discrimination of the 7 th and 8 th cranial nerves. Must have good membranous labyrinth discrimination	Must cover top of IACs to foramen magnum Coronal must cover pituitary to 4 th ventricle	Slice thickness ≤ 2.0 mm Gap = 0 mm (zero gap) In plane pixel (read) ≤ 0.7 mm In plane pixel (phase) ≤ 0.9 Pixel Area ≤ 0.6 mm ²
Axial or coronal high resolution dark fluid with fat suppression post contrast	Must have good discrimination of the 7 th and 8 th cranial nerves.	Must cover top of IACs to foramen magnum	Slice thickness ≤ 3.0 mm Gap ≤ 0.2 mm In plane pixel (read) ≤ 0.7 mm In plane pixel (phase) ≤ 0.9 mm Pixel area ≤ 0.6 mm ²
Axial or coronal high resolution dark fluid post contrast	Must have good discrimination of the 7 th and 8 th cranial nerves.	Must cover pituitary to 4 th ventricle	Slice Thickness ≤ 3.0 mm Gap ≤ 0.2 mm In plane pixel (read) ≤ 0.7 mm In plane pixel (phase) ≤ 0.9 mm Pixel area ≤ 0.6 mm ²

Brain for TIA – maximum examination time ≤ 35 minutes			
Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
Sagittal, axial or Coronal dark fluid	Must have good discrimination between the brain and cerebral spinal fluid (CSF)	<ul style="list-style-type: none"> • Axial must cover the entire brain • Sagittal must cover the entire brain from left to right and the top of the brain to the C2 level • Coronal must cover the entire brain from the anterior cranial vault to the posterior cranial vault • The midline cut must be through the aqueduct 	Slice thickness ≤ 5.0 mm Gap ≤ 2.5 mm if coronal Gap ≤ 2.0 mm if axial or sagittal In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.2 mm Pixel area ≤ 1.2 mm ²
Axial diffusion weighted imaging (DWI)	Must have a B value greater than 800	Axial must cover the entire brain	Slice thickness ≤ 5.0 mm Gap ≤ 2.0 mm In plane pixel (read) ≤ 2.0 mm In plane pixel (phase) ≤ 2.0 mm Pixel area ≤ 2.0 mm ²
Axial or coronal T2 FLAIR	Must have good contrast between the gray matter and white matter The CSF must be hypo or isointense with the white matter	<ul style="list-style-type: none"> • Axial must cover the entire brain • Coronal must cover the entire brain from the anterior cranial vault to the posterior cranial vault 	Slice thickness ≤ 5.0 mm Gap ≤ 2.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.2 mm Pixel area ≤ 1.2 mm ²
Axial bright fluid	The CSF must be hyperintense relative to the brain Must have good contrast between the gray matter and white matter	<ul style="list-style-type: none"> • Axial must cover the entire brain 	Slice thickness ≤ 5.0 mm Gap ≤ 2.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.2 mm Pixel area ≤ 1.2 mm ²
Axial or coronal T2* weighted gradient echo	The CSF must be hyperintense relative to the brain	<ul style="list-style-type: none"> • Axial must cover the entire brain • Coronal must cover the entire brain from the anterior cranial vault to the posterior cranial vault 	Slice thickness ≤ 5.0 mm Gap ≤ 2.5 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.2 mm Pixel area ≤ 1.2 mm ²

Brain for Suspected Demyelinating Disease* - maximum examination time ≤ 35 minutes

Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
Axial, sagittal or coronal dark fluid	Must have good discrimination between the brain and CSF	<ul style="list-style-type: none"> • Axial must cover convexity to foramen magnum • Coronal must cover entire brain from anterior to posterior cranial vault • Sagittal must cover entire brain from left to right and the top of the brain to the C2 level 	Slice thickness ≤ 5.0 mm Gap ≤ 2.5 mm if coronal Gap ≤ 2.0 mm if axial or sagittal In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.2 mm Pixel area ≤ 1.2 mm ²
Sagittal T2 FLAIR	Must have good water suppression The CSF must be hypo or isointense with the white matter	<ul style="list-style-type: none"> • Sagittal must cover entire brain from left to right and the top of the brain to the C2 level 	Slice thickness ≤ 5.0 mm Gap ≤ 2.0 mm In plane pixel (read) ≤ 2.0 mm In plane pixel (phase) ≤ 2.0 mm Pixel area ≤ 2.0 mm ²
Axial T2 FLAIR	Must have good water suppression The CSF must be hypo or isointense with the white matter	Axial must cover from convexity to foramen magnum	Slice thickness ≤ 5.0 mm Gap ≤ 2.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.2 mm Pixel area ≤ 1.2 mm ²
Axial bright fluid	The CSF must be hyperintense relative to the brain Must have good contrast between the gray matter and white matter	Axial must cover from convexity to foramen magnum	Slice thickness ≤ 5.0 mm Gap ≤ 2.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.2 mm Pixel area ≤ 1.2 mm ²
Axial or coronal dark fluid post contrast	Must have good discrimination between the brain and CSF	<ul style="list-style-type: none"> • Axial must cover from convexity to foramen magnum • Coronal must cover entire brain from anterior to posterior cranial vault 	Slice thickness ≤ 5.0 mm Gap ≤ 2.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.2 mm Pixel area ≤ 1.2 mm ²

Orbits for vision loss* - Maximum examination time ≤ 30 minutes			
Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
Axial dark fluid	<ul style="list-style-type: none"> • Must have good optic nerve sheath discrimination 	Must cover entire orbits and optic nerves	Slice thickness ≤ 3.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.0 mm Pixel area ≤ 1.0 mm ²
Axial bright fluid with fat suppression	<ul style="list-style-type: none"> • Must have good optic nerve discrimination • Must have good fat suppression 	Must cover entire brain	Slice thickness ≤ 5.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.0 mm Pixel area ≤ 1.0 mm ²
Coronal bright fluid STIR with fat suppression	<ul style="list-style-type: none"> • Must have good optic nerve discrimination • Must have good fat suppression 	Must cover eyelids to dorsum sella	Slice thickness ≤ 5.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.0 mm Pixel area ≤ 1.0 mm ²
Axial dark fluid with fat suppression post contrast	<ul style="list-style-type: none"> • Must have good optic nerve sheath discrimination • Must have good fat suppression 	Must cover entire orbits and optic nerves	Slice thickness ≤ 3.0mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.0 mm Pixel area ≤ 1.0 mm ²
Coronal dark fluid with fat suppression post contrast	<ul style="list-style-type: none"> • Must have good optic nerve sheath discrimination • Must have good fat suppression 	Must cover eyelids to dorsum sella	Slice thickness ≤ 5.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.0 mm Pixel area ≤ 1.0 mm ²

Pituitary with dynamic contrast enhancement* - maximum examination time ≤ 40 minutes

Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
Sagittal dark fluid	Must have good discrimination between brain and CSF	Must cover from medial temporal lobe to medial temporal lobe	Slice thickness ≤ 3.3 mm Gap ≤ 0.3 mm In plane pixel (read) ≤ 0.7 mm In plane pixel (phase) ≤ 0.9 mm Pixel area ≤ 0.6 mm ²
Coronal dark fluid	Must have good discrimination between brain and CSF	Must cover from orbital apex to dorsum sella	Slice thickness ≤ 3.3 mm Gap ≤ 0.3 mm In plane pixel (read) ≤ 0.7 mm In plane pixel (phase) ≤ 0.9 mm Pixel area ≤ 0.6 mm ²
Coronal dynamic dark fluid pre/post contrast	<ul style="list-style-type: none"> • Must have good discrimination between brain and CSF • Must have ≥ 5 sets of images in the sequence • First sequence must be pre contrast • IV contrast must be timed so there is one set of pre contrast images. There should not be more than two sets of images without contrast. 	Must cover entire pituitary	Slice thickness ≤ 3.3 mm Gap ≤ 0.3 mm In plane pixel (read) ≤ 1.4 mm In plane pixel (phase) ≤ 1.4 mm Pixel area ≤ 1.96 mm ² Temporal resolution ≤ 30 sec.
Sagittal dark fluid post contrast	Must have good discrimination between brain and CSF	Must cover medial temporal lobe to medial temporal lobe	Slice thickness ≤ 3.3 mm Gap ≤ 0.3 mm In plane pixel (read) ≤ 0.7 mm In plane pixel (phase) ≤ 0.9 mm Pixel area ≤ 0.6 mm ²
Coronal dark fluid post contrast	Must have good discrimination between brain and CSF	Must cover orbital apex to dorsum sella	Slice thickness ≤ 3.3 mm Gap ≤ 0.3 mm In plane pixel (read) ≤ 0.7 mm In plane pixel (phase) ≤ 0.9 mm Pixel area ≤ 0.6 mm ²

Thoracic Spine – maximum examination time ≤ 35 minutes

Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
Sagittal dark fluid	<ul style="list-style-type: none"> • Must not have non-anatomic heterogeneous signal intensity of the cord. • CSF must be hypointense to the cord/nerve roots so that the cord/nerve roots are clearly defined. • Must have good contrast between cord and CSF. • Fat must not be so intense that it masks the fat/muscle planes. • T1 FLAIR is acceptable for this sequence 	<ul style="list-style-type: none"> • Must cover C7 to L1 inclusive • Must cover laterally through the neural foramina 	Slice thickness ≤ 4.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.2 mm In plane pixel (phase) ≤ 1.3 mm Pixel area ≤ 1.6 mm ²
Sagittal bright fluid	<ul style="list-style-type: none"> • Must not have non-anatomic heterogeneous signal intensity of the cord. • Cerebral spinal fluid must be hyperintense to the cord/nerve roots so that the cord/nerve roots are clearly defined. • Must have good contrast between cord and CSF. 	<ul style="list-style-type: none"> • Must cover C7 to L1 inclusive • Must cover laterally through the neural foramina 	Slice thickness ≤ 4.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.2 mm In plane pixel (phase) ≤ 1.3 mm Pixel area ≤ 1.6 mm ²
Axial bright fluid - contiguous or angled	<ul style="list-style-type: none"> • Must not have non-anatomic heterogeneous signal intensity of the cord. • CSF must be hyperintense to the cord/nerve roots so that the cord/nerve roots are clearly defined. • Must have good contrast between cord and CSF. 	<ul style="list-style-type: none"> • Axials may be angled or contiguous • Angled slices must cover at least six disc spaces • Angled slices must include at least three spaces per disc • Angled slices must include center slice through the disc space • Contiguous slices must cover at least six contiguous vertebrae (inclusive). 	Slice thickness ≤ 4.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.2 mm In plane pixel (phase) ≤ 1.3 mm Pixel area ≤ 1.6 mm ²
Sagittal localizer	<ul style="list-style-type: none"> • Must be able to number the vertebrae C2 through T2. 	<ul style="list-style-type: none"> • Must include C2 through T2 	

Cervical Spine for Intramedullary Disease* - maximum examination time ≤ 40 minutes

Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
Sagittal dark fluid	<ul style="list-style-type: none"> • Should not have non-anatomic heterogeneous signal intensity of the cord. • CSF must be hypointense to the cord/nerve roots so that cord/nerve roots are clearly defined. • Fat must not be so intense that it masks the fat/muscle plane. • Must show good contrast between the cord and CSF. • T1 FLAIR is acceptable for this sequence 	<ul style="list-style-type: none"> • Must cover foramen magnum to T1. • Must cover laterally through the neural foramina. 	Slice thickness ≤ 3.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.0 mm Pixel area ≤ 1.0 mm ²
Sagittal bright fluid	<ul style="list-style-type: none"> • Should not have non-anatomic heterogeneous signal intensity of the cord. • CSF must be hyperintense to the cord/nerve roots so that cord/nerve roots are clearly defined. • Must show good contrast between the cord and CSF. 	<ul style="list-style-type: none"> • Must cover foramen magnum to T1. • Must cover laterally through the neural foramina. 	Slice thickness ≤ 3.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.0 mm Pixel area ≤ 1.0 mm ²
Axial dark fluid	<ul style="list-style-type: none"> • Should not have non-anatomic heterogeneous signal intensity of the cord. • CSF must be hypointense to the cord/nerve roots so that cord/nerve roots are clearly defined. • Fat must not be so intense that it masks the fat/muscle plane. • Must show good contrast between the cord and CSF. 	Must cover contiguously from the foramen magnum to T1	Slice thickness ≤ 3.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.0 mm Pixel area ≤ 1.0 mm ²
Axial dark fluid post contrast	<ul style="list-style-type: none"> • Should not have non-anatomic heterogeneous signal intensity of the cord. • CSF must be hypointense to the cord/nerve roots so that cord/nerve roots are clearly defined. • Fat must not be so intense that it masks the fat/muscle plane. • Must show good contrast between the cord and CSF. 	Must cover contiguously from the foramen magnum to T1	Slice thickness ≤ 3.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.0 mm Pixel area ≤ 1.0 mm ²
Sagittal dark fluid post contrast	<ul style="list-style-type: none"> • Should not have non-anatomic heterogeneous signal intensity of the cord. • CSF must be hypointense to the cord/nerve roots so that cord/nerve roots are clearly defined. • Fat must not be so intense that it masks the fat/muscle plane. • Must show good contrast between the cord and CSF. 	<ul style="list-style-type: none"> • Must cover foramen magnum to T1. • Must cover laterally through the neural foramina. 	Slice thickness ≤ 3.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.0 mm Pixel area ≤ 1.0 mm ²

Cervical Spine * - maximum examination time ≤ 35 minutes

Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
Sagittal dark fluid	<ul style="list-style-type: none"> • Should not have non-anatomic heterogeneous signal intensity of the cord. • CSF must be hypointense to the cord/nerve roots so that cord/nerve roots are clearly defined. • Fat must not be so intense that it masks the fat/muscle plane. • Must show good contrast between the cord and CSF. • T1 FLAIR is acceptable for this sequence 	<ul style="list-style-type: none"> • Must cover foramen magnum to T1. • Must cover laterally through the neural foramina. 	Slice thickness ≤ 3.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.0 mm Pixel area ≤ 1.0 mm ²
Sagittal bright fluid	<ul style="list-style-type: none"> • Should not have non-anatomic heterogeneous signal intensity of the cord. • CSF must be hyperintense to the cord/nerve roots so that cord/nerve roots are clearly defined. • Fat must not be so intense that it masks the fat/muscle plane. • Must show good contrast between the cord and CSF. 	<ul style="list-style-type: none"> • Must cover foramen magnum to T1. • Must cover laterally through the neural foramina. 	Slice thickness ≤ 3.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.0 mm Pixel area ≤ 1.0 mm ²
Axial bright fluid	<ul style="list-style-type: none"> • Should not have non-anatomic heterogeneous signal intensity of the cord. • CSF must be hyperintense to the cord/nerve roots so that cord/nerve roots are clearly defined. • Fat must not be so intense that it masks the fat/muscle plane. • Must show good contrast between the cord and CSF. 	Must cover contiguously from C3 to T1.	Slice thickness ≤ 3.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.0 mm Pixel area ≤ 1.0 mm ²

Lumbar Spine – maximum examination time ≤ 35 minutes

Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
Sagittal dark fluid	<ul style="list-style-type: none"> • Should not have non-anatomic heterogeneous signal intensity of the cord. • CSF must be hypointense to the cord/nerve roots so that cord/nerve roots are clearly defined. • Fat must not be so intense that it masks the fat/muscle plane. • Must show good contrast between the cord and CSF. • T1 FLAIR is acceptable for this sequence 	<ul style="list-style-type: none"> • Must cover T12 – S2 inclusive • Must cover from and through one pedicle, all the way through to the contra-lateral pedicle inclusive. 	Slice thickness ≤ 5.0 mm Gap ≤ 1.5 mm In plane pixel (read) ≤ 1.2 mm In plane pixel (phase) ≤ 1.2 mm Pixel area ≤ 1.5 mm ²
Sagittal bright fluid	<ul style="list-style-type: none"> • Should not have non-anatomic heterogeneous signal intensity of the cord. • CSF must be hyperintense to the cord/nerve roots so that cord/nerve roots are clearly defined. • Fat must not be so intense that it masks the fat/muscle plane. • Must show good contrast between the cord and CSF. 	<ul style="list-style-type: none"> • Must cover T12 – S2 inclusive • Must cover from and through one pedicle, all the way through to the contra-lateral pedicle inclusive. 	Slice thickness ≤ 5.0 mm Gap ≤ 1.5 mm In plane pixel (read) ≤ 1.2 mm In plane pixel (phase) ≤ 1.2 mm Pixel area ≤ 1.5 mm ²
Axial dark fluid and/or bright fluid	<ul style="list-style-type: none"> • Should not have non-anatomic heterogeneous signal intensity of the cord. • Dark fluid sequence – CSF must be hypointense to the cord/nerve roots so that cord/nerve roots are clearly defined. • Bright fluid sequence – CSF must be hyperintense to the cord/nerve roots so that cord/nerve roots are clearly defined. • Fat must not be so intense that it masks the fat/muscle plane. • Must show good contrast between the cord and CSF. 	Must cover the L3-4, L4-5, and L5-S1 levels including each disc and contiguous endplates.	Slice thickness ≤ 4.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.2 mm In plane pixel (phase) ≤ 1.2 mm Pixel area ≤ 1.5 mm ²

Female Pelvis such as for uterine or adnexal disease * - maximum examination time ≤ 35 minutes				
Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution	
This entire examination is a high resolution female pelvis protocol				
Sagittal high resolution bright fluid	<ul style="list-style-type: none"> The uterine corpus zonal anatomy must be clearly defined. The uterine cervix zonal anatomy must be clearly defined. 	Must cover the uterus, cervix, adnexa and pelvic sidewalls	Slice thickness ≤ 5.0 mm Gap ≤ 1.5 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.0 mm Pixel area ≤ 1.0 mm ²	
Axial high resolution bright fluid	<ul style="list-style-type: none"> The uterine corpus zonal anatomy must be clearly defined. The uterine cervix zonal anatomy must be clearly defined. 	<ul style="list-style-type: none"> Must cover from iliac crests to vaginal introitus Must cover pelvic sidewalls 	Slice thickness ≤ 5.0 mm Gap ≤ 1.5 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.0 mm Pixel area ≤ 1.0 mm ²	
Axial whole pelvis dark fluid	Fat must be hyperintense	Must cover entire boney pelvis laterally and antero-posteriorly	Slice thickness ≤ 5.0 mm Gap ≤ 1.5 mm In plane pixel (read) ≤ 1.5 mm In plane pixel (phase) ≤ 1.5 mm Pixel area ≤ 2.4 mm ²	
Sagittal or axial dark fluid with fat suppression	<ul style="list-style-type: none"> Fat must be hypointense All scan parameters must be identical to the post contrast 	Sagittal must cover the uterus, cervix, adnexa and pelvic sidewalls Axial must cover entire boney pelvis laterally and antero-posteriorly	If sagittal: Slice thickness ≤ 4.0 mm Gap ≤ 0.0 mm In plane pixel (read) ≤ 1.5 mm In plane pixel (phase) ≤ 1.5 mm Pixel area ≤ 2.4 mm ²	If axial: Slice thickness ≤ 5.0 mm Gap ≤ 1.5 mm In plane pixel (read) ≤ 1.5 mm In plane pixel (phase) ≤ 1.5 mm Pixel area ≤ 2.4 mm ²
Sagittal or axial dark fluid with fat suppression post contrast	<ul style="list-style-type: none"> Fat must be hypointense Must show sufficient uterine enhancement All scan parameters must be identical to the pre contrast 	Sagittal must cover the uterus, cervix, adnexa and pelvic sidewalls Axial must cover entire boney pelvis laterally and antero-posteriorly	If sagittal: Slice thickness ≤ 4.0 mm Gap ≤ 0.0 mm In plane pixel (read) ≤ 1.5 mm In plane pixel (phase) ≤ 1.5 mm Pixel area ≤ 2.4 mm ²	If axial: Slice thickness ≤ 5.0 mm Gap ≤ 1.5 mm In plane pixel (read) ≤ 1.5 mm In plane pixel (phase) ≤ 1.5 mm Pixel area ≤ 2.4 mm ²

Hepatobiliary * - maximum examination time ≤ 35 minutes

Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution	
In phase/out of phase dark fluid	<ul style="list-style-type: none"> • Must have adequate hepatic/splenic contrast • Must display appropriate signal loss on opposed- phase images. • Must have good definition of surrounding soft tissues 	Must cover the entire liver	Slice thickness ≤ 7 mm Gap ≤ 1.5 mm In plane pixel (read) ≤ 1.8 mm In plane pixel (phase) ≤ 3.6 mm Pixel area ≤ 7.2 mm ²	
Axial or coronal long TR bright fluid with or without fat suppression	<ul style="list-style-type: none"> • Must have good discrimination of liver from biliary tree. • Must have good definition of surrounding soft tissues. • Steady State Free Precession sequences, such as FIESTA and true FISP are not adequate substitutions for CSE, FSE or IR sequences at this time, and are not acceptable for this sequence. 	Must cover the entire liver	Slice thickness ≤ 7 mm Gap ≤ 1.5 mm In plane pixel (read) ≤ 1.5 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 3.75 mm ²	
MRCP 3D or 2D	<ul style="list-style-type: none"> • You may submit a 3D or 2D sequence for MRCP • Must have good fluid discrimination 	Must cover the central biliary tree including the second order branches Must cover the entire pancreas	3D Slice thickness ≤ 2.0 mm In plane pixel (read) ≤ 1.6 mm In plane pixel (phase) ≤ 1.6 mm Voxel volume ≤ 5.2 mm ³	2D thick slab Slice thickness > 40 mm, < 60 mm Gap 0.0 In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.5 mm Pixel area ≤ 1.0 mm ²
Axial 3D dark fluid dynamic with fat suppression post contrast	<ul style="list-style-type: none"> • Must have good definition of surrounding soft tissues • Must have at least four phases: <ul style="list-style-type: none"> ○ Pre contrast ○ Parenchymal arterial ○ Portal venous ○ Equilibrium or delayed 	Must cover the entire liver	Slice thickness ≤ 6.0 mm Gap 0 mm In plane pixel (read) ≤ 1.5 mm In plane pixel (phase) ≤ 3.0 mm Pixel area ≤ 4.5 mm ²	

Male Pelvis such as for prostate cancer– maximum examination time ≤ 35 minutes			
Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
Axial bright fluid high-resolution	<ul style="list-style-type: none"> • Must have good discrimination between the transition zone and peripheral zone • The peripheral zone must be hyperintense to the transition zone • The prostate capsular margin must be well defined 	Must cover the entire prostate gland and seminal vesicles	Slice thickness ≤ 4.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.2 mm In plane pixel (phase) ≤ 1.2 mm Pixel area ≤ 1.5 mm ²
Coronal or sagittal bright fluid high resolution	<ul style="list-style-type: none"> • Must have good discrimination between the transition zone and peripheral zone • The peripheral zone must be hyperintense to the transition zone • The prostate capsular margin must be well defined 	Must cover the entire prostate gland and seminal vesicles	Slice thickness ≤ 4.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.2 mm In plane pixel (phase) ≤ 1.2 mm Pixel area ≤ 1.5 mm ²
Axial dark fluid high-resolution	<ul style="list-style-type: none"> • There must be good contrast between the periprostatic fat and capsule • The prostate capsular margin must be well defined 	Must cover the entire prostate gland and seminal vesicles	Slice thickness ≤ 4.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 1.2 mm In plane pixel (phase) ≤ 1.2 mm Pixel area ≤ 1.5 mm ²
Axial whole pelvis dark fluid	<ul style="list-style-type: none"> • The bone marrow must be hyperintense to the muscle • There must be good contrast between the lymph nodes and the retroperitoneal fat 	<ul style="list-style-type: none"> • Must cover the ischial tuberosities to the iliac crest • Must cover the entire bony pelvis laterally and antero-posteriorly 	Slice thickness ≤ 5.0 mm Gap ≤ 1.5 mm In plane pixel (read) ≤ 1.5 mm In plane pixel (phase) ≤ 1.5 mm Pixel area ≤ 2.4 mm ²

Renal – maximum examination time ≤ 35 minutes

Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
Axial or coronal bright fluid with fat suppression	Must have good discrimination between the kidney and the collecting system	<ul style="list-style-type: none"> • Axial must cover both adrenal glands and kidneys entirely • Coronal must cover both kidneys anterior to posterior 	Slice thickness ≤ 7.0 mm Gap ≤ 1.5 mm In plane pixel (read) ≤ 1.5 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 3.75 mm ²
Axial in-phase/oppose d-phase dark fluid	<ul style="list-style-type: none"> • Must have good cortico-medullary discrimination • Must have good definition of surrounding tissues 	Must cover both adrenal glands and kidneys entirely	Slice thickness ≤ 7.0 mm Gap ≤ 1.5 mm In plane pixel (read) ≤ 1.8 mm In plane pixel (phase) ≤ 3.6 mm Pixel area ≤ 7.2 mm ²
Dynamic axial or coronal dark fluid with fat suppression post contrast	<ul style="list-style-type: none"> • Must have sufficient IV contrast enhancement of the renal parenchyma over time • Must include a pre-contrast phase 	<ul style="list-style-type: none"> • Axial must cover both adrenal glands and kidneys entirely • Coronal must cover both kidneys anterior to posterior 	Slice thickness ≤ 5.0 mm Gap ≤ 1.5 mm In plane pixel (read) ≤ 1.5 mm In plane pixel (phase) ≤ 1.5 mm Pixel area ≤ 2.4 mm ²

Elbow for internal derangement * - maximum examination time ≤ 45 minutes

Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
Axial dark fluid or long TR/short TE	<ul style="list-style-type: none"> • Trabeculae and cortex must be sharply defined • Must have good definition of surrounding tissues • Must have good contrast between fat and non-fat tissues • Tendons must be well discriminated <ul style="list-style-type: none"> ○ Biceps and brachialis tendon ○ Common flexor and extensor tendon ○ Triceps tendon 	<ul style="list-style-type: none"> • Images must be perpendicular to the long axis of the elbow • Must cover the entire soft tissues of the elbow • Must cover from above the humeral epicondyles to the biceps tendon insertion and radial tuberosity 	Slice thickness ≤ 4.0 mm Gap ≤ 1.2 mm In plane pixel (read) ≤ 0.6 mm In plane pixel (phase) ≤ 0.6 mm Pixel area ≤ 0.4 mm ²
Axial STIR or bright fluid with or without fat suppression	<ul style="list-style-type: none"> • Trabeculae and cortex must be sharply defined • Must have good definition of surrounding tissues • Tendons must be well discriminated <ul style="list-style-type: none"> ○ Biceps and brachialis tendon ○ Common flexor and extensor tendon ○ Triceps tendon 	<ul style="list-style-type: none"> • Images must be perpendicular to the long axis of the elbow • Must cover the entire soft tissues of the elbow • Must cover from above the humeral epicondyles to the biceps tendon insertion and radial tuberosity 	Slice thickness ≤ 4.0 mm Gap ≤ 1.2 mm In plane pixel (read) ≤ 0.6 mm In plane pixel (phase) ≤ 0.6 mm Pixel area ≤ 0.4 mm ²
Coronal dark fluid or long TR/short TE	<ul style="list-style-type: none"> • Trabeculae and cortex must be sharply defined • Must have good definition of surrounding tissues • Must have good contrast between fat and non-fat tissues • Must have good cartilage visualization • Must have good definition of collateral ligaments • Must have good discrimination of common flexor and extensor tendons 	<ul style="list-style-type: none"> • Images must be parallel to the epicondylar axis as prescribed from the axial image • Must cover the entire soft tissues of the elbow • Must cover from above the humeral epicondyles to the biceps tendon insertion and radial tuberosity 	Slice thickness ≤ 3.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 0.6 mm In plane pixel (phase) ≤ 0.6 mm Pixel area ≤ 0.4 mm ²
Coronal STIR or bright fluid with fat suppression	<ul style="list-style-type: none"> • Cortex must be sharply defined • Must have good definition of surrounding soft tissues • Must have good discrimination of <ul style="list-style-type: none"> ○ Fluid vs. soft tissue ○ Common flexor and extensor tendon ○ Cartilage vs. joint fluid • Must have good definition of collateral ligaments 	<ul style="list-style-type: none"> • Images must be parallel to the epicondylar axis as prescribed from the axial image • Must cover the entire soft tissues of the elbow • Must cover from above the humeral epicondyles to the biceps tendon insertion and radial tuberosity 	Slice thickness ≤ 3.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 0.6 mm In plane pixel (phase) ≤ 0.6 mm Pixel area ≤ 0.4 mm ²
Sagittal bright fluid	<ul style="list-style-type: none"> • Trabeculae and cortex must be sharply defined • Must have good definition of surrounding tissues • Must have good discrimination of <ul style="list-style-type: none"> ○ Triceps tendon ○ Biceps tendon ○ Cartilage from joint fluid 	<ul style="list-style-type: none"> • Images must be perpendicular to the epicondylar axis as prescribed from the axial image • Must cover the entire soft tissues of the elbow • Must cover from above the humeral epicondyles to the biceps tendon insertion and radial tuberosity 	Slice thickness ≤ 3.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 0.6 mm In plane pixel (phase) ≤ 0.6 mm Pixel area ≤ 0.4 mm ²

Forefoot for Morton's Neuroma * - maximum examination time ≤ 45 minutes

Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
Short axis dark fluid (perpendicular to the metatarsals)	<ul style="list-style-type: none"> • Must have good definition of trabeculae and cortex • Must have good definition of surrounding soft tissues • Must have good contrast between fat and non-fat tissues • Must have good discrimination of tendons • Must visualize metatarsophalangeal joint capsule • Must have good visualization of plantar plate 	<ul style="list-style-type: none"> • Must include proximal interphalangeal joint (PIP) • Must include at least the distal half of all metatarsals • Must align perpendicular to the long axis of the metatarsals • Must cover entire soft tissues of the forefoot 	Slice thickness ≤ 3.0 mm Gap ≤ 0.3 mm In plane pixel (read) ≤ 0.6 mm In plane pixel (phase) ≤ 0.6 mm Pixel area ≤ 0.4 mm ²
Short axis bright fluid (perpendicular to the metatarsals)	<ul style="list-style-type: none"> • Must have good definition of trabeculae and cortex • Must have good definition of surrounding soft tissues • Must have good contrast between fat and non-fat tissues • Must have good discrimination of tendons • Must visualize metatarsophalangeal joint capsule • Must have good visualization of plantar plate 	<ul style="list-style-type: none"> • Must include proximal interphalangeal joint (PIP) • Must include at least the distal half of all metatarsals • Must align perpendicular to the long axis of the metatarsals • Must cover entire soft tissues of the forefoot 	Slice thickness ≤ 3.0 mm Gap ≤ 0.3 mm In plane pixel (read) ≤ 0.6 mm In plane pixel (phase) ≤ 0.6 mm Pixel area ≤ 0.4 mm ²
Short axis (perpendicular to the metatarsals) STIR or bright fluid with fat suppression	<ul style="list-style-type: none"> • Must have good definition of cortex • Must have good definition of surrounding soft tissues • Must have good contrast between tissue and fluid • Must have good discrimination of tendons • Must visualize metatarsophalangeal joint capsule • Must have good visualization of plantar plate 	<ul style="list-style-type: none"> • Must include proximal interphalangeal joint (PIP) • Must include at least the distal half of all metatarsals • Must align perpendicular to the long axis of the metatarsals • Must cover entire soft tissues of the forefoot 	Slice thickness ≤ 3.0 mm Gap ≤ 0.3 mm In plane pixel (read) ≤ 0.6 mm In plane pixel (phase) ≤ 0.6 mm Pixel area ≤ 0.4 mm ²
Long axis (parallel to the metatarsals and plantar surface) STIR or bright fluid with fat suppression	<ul style="list-style-type: none"> • Must have good definition of cortex • Must have good definition of surrounding soft tissues • Must have good contrast between tissue and fluid • Must have good discrimination of tendons • Must visualize metatarsophalangeal joint capsule 	<ul style="list-style-type: none"> • Must include tips of toes • Must include at least the distal half of all metatarsals • Must align parallel to the long axis of the metatarsals • Must cover entire soft tissues of the forefoot 	Slice thickness ≤ 3.0 mm Gap ≤ 0.3 mm In plane pixel (read) ≤ 0.6 mm In plane pixel (phase) ≤ 0.6 mm Pixel area ≤ 0.4 mm ²
Sagittal (Parallel to the metatarsals)	<ul style="list-style-type: none"> • Must have good definition of trabeculae and cortex • Must have good definition of surrounding soft tissues • Must have good discrimination of tendons 	<ul style="list-style-type: none"> • Must include tips of toes • Must include at least the distal half of all metatarsals • Must align perpendicular to the long axis sequence and parallel to the long axis of the metatarsals • Must cover entire soft tissues of the forefoot 	Slice thickness ≤ 3.0 mm Gap ≤ 0.3 mm In plane pixel (read) ≤ 0.6 mm In plane pixel (phase) ≤ 0.6 mm Pixel area ≤ 0.4 mm ²

Shoulder for internal derangement – maximum examination time ≤ 35 minutes

Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
Coronal oblique dark fluid	<ul style="list-style-type: none"> • Must have good definition of trabeculae and cortex • Must have good definition of surrounding soft tissues • Must have good definition of labrum • Must have good definition of tendons <ul style="list-style-type: none"> ○ Supraspinatus ○ Infraspinatus ○ Subscapularis 	<ul style="list-style-type: none"> • Must be parallel to supraspinatus tendon as seen on axial cut through the superior portion of the shoulder or perpendicular to the articular surface of the glenoid fossa as seen on axial images • Must include the teres minor muscle posterior to the humeral head through the anterior coracoid tip 	Slice thickness ≤ 4.0 mm Gap ≤ 0.8 mm In plane pixel (read) ≤ 0.7 mm In plane pixel (phase) ≤ 1.0 mm Pixel area ≤ 0.8 mm ²
Axial long TR/short TE	<ul style="list-style-type: none"> • Must have good definition of trabeculae and cortex • Must have good definition of surrounding soft tissues • Must have good definition of labrum • Must have good definition of biceps in bicipital groove 	Must cover from the top of the acromion to the bottom of the glenohumeral joint using the coronal scout image as a localizer	Slice thickness ≤ 4.0 mm Gap ≤ 0.8 mm In plane pixel (read) ≤ 0.7 mm In plane pixel (phase) ≤ 1.0 mm Pixel area ≤ 0.8 mm ²
Coronal oblique bright fluid with fat suppression	<ul style="list-style-type: none"> • Must have homogeneous fat saturation • Must have good definition of trabeculae and cortex • Must have good definition of surrounding soft tissues • Must have good definition of labrum • Must have good definition of tendons <ul style="list-style-type: none"> ○ Supraspinatus ○ Infraspinatus ○ Subscapularis 	<ul style="list-style-type: none"> • Must be parallel to supraspinatus tendon as seen on axial cut through the superior portion of the shoulder or perpendicular to the articular surface of the glenoid fossa as seen on axial images • Must include the teres minor muscle posteriorly to the humeral head through the anterior coracoid tip 	Slice thickness ≤ 4.0 mm Gap ≤ 0.8 mm In plane pixel (read) ≤ 0.7 mm In plane pixel (phase) ≤ 1.0 mm Pixel area ≤ 0.8 mm ²
Sagittal oblique bright fluid	<ul style="list-style-type: none"> • Must have good definition of trabeculae and cortex • Must have good definition of surrounding soft tissues • Must have good definition of rotator interval • Must have good definition of tendons <ul style="list-style-type: none"> ○ Supraspinatus ○ Infraspinatus ○ Subscapularis ○ Teres minor ○ Biceps 	<ul style="list-style-type: none"> • Must be parallel to the articular surface of the glenoid fossa as seen on the axial images • Must cover the scapular neck through the lateral margin of the humerus 	Slice thickness ≤ 4.0 mm Gap ≤ 0.8 mm In plane pixel (read) ≤ 0.7 mm In plane pixel (phase) ≤ 1.0 mm Pixel area ≤ 0.8 mm ²

Wrist for internal derangement* - maximum examination time ≤ 40 minutes

Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
Coronal oblique dark fluid	<ul style="list-style-type: none"> • Must have good definition of trabeculae and cortex • Must have good definition of surrounding soft tissues • Must have good definition of <ul style="list-style-type: none"> ○ Scapholunate ligament ○ Triangular fibrocartilage complex 	<ul style="list-style-type: none"> • Must cover entire wrist including extrinsic ligaments and tendons • Must cover from Lister's tubercle through the bases of the metacarpals 	Slice thickness ≤ 3.0 mm Gap ≤ 0.5 mm In plane pixel (read) ≤ 0.4 mm In plane pixel (phase) ≤ 0.6 mm Pixel area ≤ 0.3 mm ²
Coronal oblique bright fluid	<ul style="list-style-type: none"> • Must have bright fluid • Must have good definition of trabeculae and cortex • Must have good definition of surrounding soft tissues • Must have good definition of tendons <ul style="list-style-type: none"> ○ Scapholunate ligament ○ Triangular fibrocartilage complex 	<ul style="list-style-type: none"> • Must cover entire wrist including extrinsic ligaments and tendons • Must cover from Lister's tubercle through the bases of the metacarpals 	Slice thickness ≤ 3.0 mm Gap ≤ 0.5 mm In plane pixel (read) ≤ 0.4 mm In plane pixel (phase) ≤ 0.6 mm Pixel area ≤ 0.3 mm ²
Axial dark fluid or long TR/short TE	<ul style="list-style-type: none"> • Must have good definition of trabeculae and cortex • Must have good definition of surrounding soft tissues • Must have good definition of individual extensor tendons 	<ul style="list-style-type: none"> • Must cover entire soft tissues anterior through posterior • Must cover distal radioulnar joint through the bases of the metacarpals 	Slice thickness ≤ 3.0 mm Gap ≤ 0.6 mm In plane pixel (read) ≤ 0.4 mm In plane pixel (phase) ≤ 0.6 mm Pixel area ≤ 0.3 mm ²
Axial bright fluid	<ul style="list-style-type: none"> • Fluid must be bright • Must have good definition of trabeculae and cortex • Must have good definition of surrounding soft tissues • Must have good definition of individual extensor tendons 	<ul style="list-style-type: none"> • Must cover entire soft tissues anterior through posterior • Must cover distal radioulnar joint through the bases of the metacarpals 	Slice thickness ≤ 3.0 mm Gap ≤ 0.6 mm In plane pixel (read) ≤ 0.4 mm In plane pixel (phase) ≤ 0.6 mm Pixel area ≤ 0.3 mm ²
Sagittal	<ul style="list-style-type: none"> • Must have good definition of trabeculae and cortex • Must have good definition of surrounding soft tissues 	<ul style="list-style-type: none"> • Must cover entire soft tissues anterior through posterior • Must cover distal radioulnar joint through the bases of the metacarpals 	Slice thickness ≤ 3.0 mm Gap ≤ 0.6 mm In plane pixel (read) ≤ 0.4 mm In plane pixel (phase) ≤ 0.6 mm Pixel area ≤ 0.3 mm ²

KNEE such as for internal derangement – maximum examination time ≤ 30 minutes			
Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
Must have fat suppression on at least one sagittal or coronal sequence			
Sagittal bright fluid with or without fat suppression (for evaluation of menisci and articular cartilage)	<ul style="list-style-type: none"> • Must have good definition of trabeculae and cortex • Must have good definition of menisci, cruciate ligaments and collateral ligaments • Must have good contrast between joint fluid and articular cartilage • Must have good contrast between menisci and articular cartilage • Must have good contrast between menisci and joint fluid 	Must cover entire knee from above patella to tibial tubercle and through entire menisci	Slice thickness ≤ 4.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 0.7 mm In plane pixel (phase) ≤ 0.9 mm Pixel area ≤ 0.6 mm ²
Coronal bright fluid with or without fat suppression (for evaluation of menisci and articular cartilage)	<ul style="list-style-type: none"> • Must have good definition of trabeculae and cortex • Must have good definition of menisci, cruciate ligaments and collateral ligaments • Must have good contrast between joint fluid and articular cartilage • Must have good contrast between menisci and articular cartilage • Must have good contrast between menisci and joint fluid 	Must cover entire knee from above patella to tibial tubercle and through entire menisci	Slice thickness ≤ 4.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 0.7 mm In plane pixel (phase) ≤ 0.9 mm Pixel area ≤ 0.6 mm ²
Axial bright fluid with or without fat suppression	<ul style="list-style-type: none"> • Must have good definition of trabeculae and cortex • Must have good definition of cruciate ligaments and collateral ligaments • Must have good contrast between joint fluid and articular cartilage • Must have bright fluid 	Must cover entire knee from above patella to tibial tubercle	Slice thickness ≤ 4.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 0.7 mm In plane pixel (phase) ≤ 0.9 mm Pixel area ≤ 0.6 mm ²
Sagittal bright fluid long TR/long TE with or without fat suppression (for evaluation of tendon tear)	<ul style="list-style-type: none"> • Must have good definition of trabeculae and cortex • Must have good definition of menisci, cruciate ligaments and collateral ligaments • Must have good definition of surrounding tissues • Must have bright fluid relative to articular and fibrous cartilage 	Must cover entire knee from above patella to tibial tubercle and through entire menisci	Slice thickness ≤ 4.0 mm Gap ≤ 1.0 mm In plane pixel (read) ≤ 0.7 mm In plane pixel (phase) ≤ 0.9 mm Pixel area ≤ 0.6 mm ²

MRA Abdomen for renal artery stenosis – maximum examination time ≤ 20 minutes			
Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
Black or bright blood source images	<ul style="list-style-type: none"> • Must have good artery to background contrast • Must have uniform artery signal • If performed post contrast, must be acquired during equilibrium phase 	Must cover: <ul style="list-style-type: none"> • Entire abdominal aorta • Origin of celiac artery • Origin of superior mesenteric artery (SMA) • Right and left renal arteries • Right and left common iliac arteries 	Slice thickness ≤ 7.0 mm Gap ≤ 1.5 mm In plane pixel (read) ≤ 1.5 mm In plane pixel (phase) ≤ 2.0 mm Pixel area ≤ 3.0 mm ²
3D contrast enhanced Source Images	<ul style="list-style-type: none"> • Must have good artery to background contrast • Must have uniform artery signal • Must have minimal to no venous enhancement • Must have correct bolus timing 	Must cover: <ul style="list-style-type: none"> • Entire abdominal aorta • Origin of celiac artery • Origin of superior mesenteric artery (SMA) • Right and left renal arteries to the branching in the renal hilum with no motion blurring • Right and left common iliac arteries to the iliac bifurcation 	Slice thickness ≤ 3.0 mm Reconstructed slice interval ≤ 1.5 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 2.2 mm Voxel volume ≤ 6.0 mm ³
3D contrast enhanced reformatted Images (Angiographic Images)	<ul style="list-style-type: none"> • Must have good artery to background contrast • Must have uniform artery signal 	Must display: <ul style="list-style-type: none"> • Entire abdominal aorta • Origin of celiac artery • Origin of superior mesenteric artery (SMA) • Right and left renal arteries • Right and left common iliac arteries 	N/A

MRA Arch/Carotid* – maximum examination time ≤ 20 minutes

Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
3D contrast enhanced source images	<ul style="list-style-type: none"> • Must have good artery to background contrast • Must have uniform artery signal/ minimal to no intra-voxel phase dispersion • Must have minimal to no venous enhancement • Must have correct bolus timing 	Must cover: <ul style="list-style-type: none"> • Aortic arch • Innominate artery • Right and left common carotid artery • Right and left carotid bifurcation • Right and left Subclavian arteries 2 cm distal to the vertebral origins • Right and left vertebral arteries • Basilar artery • Circle of Willis 	Slice thickness ≤ 1.5 mm Reconstructed slice interval ≤ 0.75 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 2.0 mm Voxel volume ≤ 3.0 mm ³
Reformatted images (angiographic images)	<ul style="list-style-type: none"> • Must have good artery to background contrast • Must have uniform artery signal • Must have minimal to no venous enhancement 	Must display in multiple views: <ul style="list-style-type: none"> • Aortic arch • Innominate artery • Right and left common carotid artery • Right and left carotid bifurcation (each must be displayed in separate MIP reconstructions) • Right and left Subclavian arteries 2 cm distal to the vertebral origins • Right and left vertebral arteries • Basilar artery • Circle of Willis 	N/A

MRA Brain – maximum examination time ≤ 20 minutes

Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
3d TOF source images multi-slab	<ul style="list-style-type: none"> • Must have good artery to background contrast • Must have minimal intra-voxel phase dispersion • Must have minimal to no venous signal • Must have minimal in-plane saturation 	<p>Must cover:</p> <ul style="list-style-type: none"> • Entire carotid siphon (right and left anterior subvolumes) • M1 and A1 segments (right and left anterior subvolumes) • Middle cerebral artery trifurcation and M2 branches (right and left anterior subvolumes) • Vertebral artery basilar to PICA • Posterior inferior cerebral artery (PICA) • Basilar artery • P1 and P2 segments of posterior cerebral artery 	<p>Slice thickness ≤ 1.5 mm In plane pixel (read) ≤ 0.9 mm In plane pixel (phase) ≤ 0.9 mm Voxel volume ≤ 1.2 mm³</p>
Reformatted images (angiographic images)	<ul style="list-style-type: none"> • Must have good artery to background contrast • Must have uniform artery signal/minimal intra-voxel phase dispersion • Must have minimal to no venous signal • Must have minimal in-plane saturation 	<p>Must display in multiple views:</p> <ul style="list-style-type: none"> • Entire carotid siphon (right and left anterior subvolumes) • M1 and A1 segments (right and left anterior subvolumes) • Middle cerebral artery trifurcation and M2 branches (right and left anterior subvolumes) • Vertebral artery basilar to PICA • Posterior inferior cerebral artery (PICA) • Basilar artery • P1 and P2 segments of posterior cerebral artery 	<p>N/A</p>

MRA Carotid – maximum examination time ≤ 20 minutes			
Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
3D time of flight source images	<ul style="list-style-type: none"> • Must have good artery to background contrast • Must have uniform artery signal • Must have minimal to no venous signal 	Must cover: <ul style="list-style-type: none"> • 2 cm of the right and left common carotid arteries • 3 cm of the right and left internal carotid arteries • 2 cm of the right and left external carotid arteries 	Slice thickness ≤ 1.6 mm In plane pixel (read) ≤ 0.9 mm In plane pixel (phase) ≤ 1.2 mm Voxel volume ≤ 1.7 mm ³
3D time of flight reformatted images (angiographic images)	<ul style="list-style-type: none"> • Must have good artery to background contrast • Must have uniform artery signal • Must have minimal to no venous signal 	<ul style="list-style-type: none"> • Must display in multiple views: <ul style="list-style-type: none"> ○ 2 cm of the right and left common carotid arteries ○ 3 cm of the right and left internal carotid arteries ○ 2 cm of the right and left external carotid arteries • Must show adequate segmentation of arteries such that each artery segment is visible in multiple views with no overlap from other vessels • The right and left carotid should be segmented separately 	N/A
2D time of flight multi slab source images	<ul style="list-style-type: none"> • Must have good artery to background contrast • Must have uniform artery signal • Must have minimal to no venous signal 	Must cover: <ul style="list-style-type: none"> • 4 cm of the right and left common carotid arteries • right and left internal carotid arteries to the petrous bone • right and left external carotid arteries • right and left vertebral arteries 	Slice thickness ≤ 1.2 mm Gap ≤ 0 mm In plane pixel (read) ≤ 0.9 mm In plane pixel (phase) ≤ 1.2 mm Pixel area ≤ 1.1 mm ²
2D time of flight reformatted images (angiographic images)	<ul style="list-style-type: none"> • Must have good artery to background contrast • Must have uniform artery signal • Must have minimal to no venous signal 	<ul style="list-style-type: none"> • Must display in multiple views: <ul style="list-style-type: none"> • 4 cm of the right and left common carotid arteries • right and left internal carotid arteries to the petrous bone • right and left external carotid arteries • right and left vertebral arteries • Must show adequate segmentation of arteries such that each artery segment is visible in multiple views with no overlap from other vessels • The right and left carotid and posterior circulation should be segmented separately 	N/A

MRA Thoracic Aorta – maximum examination time ≤ 20 minutes			
Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
Non contrast black or bright blood source images	<ul style="list-style-type: none"> • Must have good artery to background contrast • Must have uniform artery signal • Must have minimal to no venous signal 	Must cover: <ul style="list-style-type: none"> • 2 cm of the origins of the arch vessels • Entire thoracic aorta from the aortic annulus to the diaphragmatic hiatus 	Slice thickness ≤ 7.0 mm Gap ≤ 1.5 mm In plane pixel (read) ≤ 1.5 mm In plane pixel (phase) ≤ 2.0 mm Pixel area ≤ 3.0 mm ²
3D contrast enhanced source images	<ul style="list-style-type: none"> • Must have good artery to background contrast • Must have uniform artery signal • Must have minimal to no venous enhancement • Must have correct bolus timing 	Must cover: <ul style="list-style-type: none"> • 2 cm of the origins of the arch vessels • Entire thoracic aorta from the aortic annulus to the diaphragmatic hiatus 	Slice thickness ≤ 3.4 mm Reconstructed slice interval ≤ 1.7 mm In plane pixel (read) ≤ 3.0 mm In plane pixel (phase) ≤ 2.0 mm Voxel volume ≤ 20.0 mm ³
3D contrast enhanced reformatted images (angiographic images)	<ul style="list-style-type: none"> • Must have good artery to background contrast • Must have uniform artery signal • Must have minimal to no venous enhancement 	Must display in multiple views: <ul style="list-style-type: none"> • 2 cm of the origins of the arch vessels • Entire thoracic aorta from the aortic annulus to the diaphragmatic hiatus 	N/A

MRA Distal Peripheral Runoff – maximum examination time ≤ 20 minutes			
Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
Calf 3D contrast enhanced source images	<ul style="list-style-type: none"> • Must have good artery to background contrast • Must have uniform artery signal • Must have minimal to no venous enhancement • Must have correct bolus timing 	Must cover: <ul style="list-style-type: none"> • Knee joint down to trifurcation • Tibial arteries 	Slice thickness ≤ 2.5 mm Gap ≤ 0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.5 mm Voxel volume ≤ 4.0 mm ³
Calf reformatted images (angiographic images)	<ul style="list-style-type: none"> • Must have good artery to background contrast • Must have uniform artery signal • Must have minimal to no venous enhancement 	Must display in at least three views: <ul style="list-style-type: none"> • Knee joint down to trifurcation • Tibial arteries 	N/A
Foot source images	<ul style="list-style-type: none"> • Must have good artery to background contrast • Must have uniform artery signal • Must have minimal to no venous enhancement • Must have correct bolus timing (if 3D) 	Must cover: <ul style="list-style-type: none"> • Dorsalis pedis and lateral plantar arteries • Pedal arch 	Slice thickness ≤ 2.5 mm Gap ≤ 0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 1.5 mm Voxel volume ≤ 4.0 mm ²
Foot reformatted images	<ul style="list-style-type: none"> • Must have good artery to background contrast • Must have uniform artery signal • Must have minimal to no venous enhancement 	Must display in at least three views: <ul style="list-style-type: none"> • Dorsalis pedis and lateral plantar arteries • Pedal arch 	N/A

Black Blood			
Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
BLACK BLOOD - Axial	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Must be T1 (1 R-R/short TE) or proton density weighted (2 R-R/short TE) • Must be in the axial plane • Must have good myocardium discrimination (including good blood suppression) • TE can be optimized for your system, but should be proton density/ T1 weighted (less than approximately 45 msec). • Note that single shot (e.g., "HASTE", "<u>SSFSE</u>" or "<u>SSTSE</u>") imaging technique is not acceptable. 	Must cover from aortic root to diaphragm (axial)	Slice thickness \leq 8.0 mm Gap \leq 4 mm In plane pixel (read) \leq 1.6 mm In plane pixel (phase) \leq 2.5 mm Pixel area \leq 4.0 mm ²

Basic Cardiac			
Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
SHORT AXIS CINE	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Real time cine images are not acceptable • Must show entire systolic cycle • Must have good myocardium discrimination (including good blood suppression) • Must image end systole and end diastole • Steady State free precession technique is preferred, but fast gradient echo is allowed 	Must cover entire left ventricle from base to apex	Slice thickness ≤ 8.0 mm In plane pixel (read) ≤ 1.6 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ² Temporal resolution ≤ 80 msec (without view sharing)
LONG AXIS CINE 2 Chamber	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Real time cine images are not acceptable • Must show entire systolic cycle • Must have good myocardium discrimination (including good blood suppression) • Must image end systole and end diastole • Steady State free precession technique is preferred, but fast gradient echo is allowed 	Single slice oriented vertically through the middle portion of the left atrium and the middle portion of the left ventricle	Slice thickness ≤ 8.0 mm In plane pixel (read) ≤ 1.6 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ² Temporal resolution ≤ 80 msec (without view sharing)
LONG AXIS CINE 4 Chamber	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Real time cine images are not acceptable • Must show entire systolic cycle • Must have good myocardium discrimination (including good blood suppression) • Must image end systole and end diastole • Steady State free precession technique is preferred, but fast gradient echo is allowed 	Single slice oriented vertically through the middle portion of the left atrium and the middle portion of the left ventricle	Slice thickness ≤ 8.0 mm In plane pixel (read) ≤ 1.6 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ² Temporal resolution ≤ 80 msec (without view sharing)
LONG AXIS CINE Aortic Outflow Tract	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Real time cine images are not acceptable • Must show entire systolic cycle • Must have good myocardium discrimination (including good blood suppression) • Must image end systole and end diastole • Steady State free precession technique is preferred, but fast gradient echo is allowed 	Single slice oriented vertically through the middle portion of the left atrium and the middle portion of the left ventricle	Slice thickness ≤ 8.0 mm In plane pixel (read) ≤ 1.6 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ² Temporal resolution ≤ 80 msec (without view sharing)

Delayed Enhanced Cine 1

Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
SHORT AXIS CINE	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Real time cine images are not acceptable • Must show entire systolic cycle • Must have good myocardium discrimination (including good blood suppression) • Must image end systole and end diastole • Steady State free precession technique is preferred, but fast gradient echo is allowed 	Must cover entire left ventricle from base to apex	Slice thickness ≤ 8.0 mm In plane pixel (read) ≤ 1.6 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ² Temporal resolution ≤ 80 msec (without view sharing)
LONG AXIS CINE 2 Chamber	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Real time cine images are not acceptable • Must show entire systolic cycle • Must have good myocardium discrimination (including good blood suppression) • Must image end systole and end diastole • Steady State free precession technique is preferred, but fast gradient echo is allowed 	Single slice oriented vertically through the middle portion of the left atrium and the middle portion of the left ventricle	Slice thickness ≤ 8.0 mm In plane pixel (read) ≤ 1.6 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ² Temporal resolution ≤ 80 msec (without view sharing)
LONG AXIS CINE 4 Chamber	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Real time cine images are not acceptable • Must show entire systolic cycle • Must have good myocardium discrimination (including good blood suppression) • Must image end systole and end diastole • Steady State free precession technique is preferred, but fast gradient echo is allowed 	Single slice oriented vertically through the middle portion of the left atrium and the middle portion of the left ventricle	Slice thickness ≤ 8.0 mm In plane pixel (read) ≤ 1.6 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ² Temporal resolution ≤ 80 msec (without view sharing)
LONG AXIS CINE Aortic Outflow Tract	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Real time cine images are not acceptable • Must show entire systolic cycle • Must have good myocardium discrimination (including good blood suppression) • Must image end systole and end diastole • Steady State free precession technique is preferred, but fast gradient echo is allowed 	Single slice oriented vertically through the middle portion of the left atrium and the middle portion of the left ventricle	Slice thickness ≤ 8.0 mm In plane pixel (read) ≤ 1.6 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ² Temporal resolution ≤ 80 msec (without view sharing)
DELAYED GADOLINIUM ENHANCED	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Must be in the short axis plane in patients with prior myocardial infarction • Inversion prepared gradient echo pulse sequence • Must choose T1 so that there is good suppression of normal myocardium • Must show sufficient contrast between normal myocardium and scar 	Must cover entire left ventricle from base to apex in the short axis	Slice thickness ≤ 10.0 mm Gap ≤ 2.0 mm In plane pixel (read) ≤ 1.9 mm In plane pixel (phase) ≤ 3.1 mm Pixel area ≤ 5.9 mm ²

Delayed Enhanced Cine 2

Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
SHORT AXIS CINE	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Real time cine images are not acceptable • Must show entire systolic cycle • Must have good myocardium discrimination (including good blood suppression) • Must image end systole and end diastole • Steady State free precession technique is preferred, but fast gradient echo is allowed 	Must cover entire left ventricle from base to apex	Slice thickness ≤ 8.0 mm In plane pixel (read) ≤ 1.6 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ² Temporal resolution ≤ 80 msec (without view sharing)
LONG AXIS CINE 2 Chamber	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Real time cine images are not acceptable • Must show entire systolic cycle • Must have good myocardium discrimination (including good blood suppression) • Must image end systole and end diastole • Steady State free precession technique is preferred, but fast gradient echo is allowed 	Single slice oriented vertically through the middle portion of the left atrium and the middle portion of the left ventricle	Slice thickness ≤ 8.0 mm In plane pixel (read) ≤ 1.6 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ² Temporal resolution ≤ 80 msec (without view sharing)
LONG AXIS CINE 4 Chamber	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Real time cine images are not acceptable • Must show entire systolic cycle • Must have good myocardium discrimination (including good blood suppression) • Must image end systole and end diastole • Steady State free precession technique is preferred, but fast gradient echo is allowed 	Single slice oriented vertically through the middle portion of the left atrium and the middle portion of the left ventricle	Slice thickness ≤ 8.0 mm In plane pixel (read) ≤ 1.6 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ² Temporal resolution ≤ 80 msec (without view sharing)
LONG AXIS CINE Aortic Outflow Tract	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Real time cine images are not acceptable • Must show entire systolic cycle • Must have good myocardium discrimination (including good blood suppression) • Must image end systole and end diastole • Steady State free precession technique is preferred, but fast gradient echo is allowed 	Single slice oriented vertically through the middle portion of the left atrium and the middle portion of the left ventricle	Slice thickness ≤ 8.0 mm In plane pixel (read) ≤ 1.6 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ² Temporal resolution ≤ 80 msec (without view sharing)
DELAYED GADOLINIUM ENHANCED	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Must be in the short axis plane in patients with prior myocardial infarction • Inversion prepared gradient echo pulse sequence • Must choose T1 so that there is good suppression of normal myocardium • Must show sufficient contrast between normal myocardium and scar 	Must cover entire left ventricle from base to apex in the short axis	Slice thickness ≤ 10.0 mm Gap ≤ 2.0 mm In plane pixel (read) ≤ 1.9 mm In plane pixel (phase) ≤ 3.1 mm Pixel area ≤ 5.9 mm ²

Delayed Enhanced Cine with Black Blood*

Required Sequences	Category A: Pulse Sequence and Image Contrast	Category C: Anatomic coverage and imaging planes <i>Failure to meet these specifications will result in failure.</i>	Category D: Spatial Resolution
BLACK BLOOD - Axial	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Must be T1 (1 R-R/short TE) or proton density weighted (2 R-R/short TE) • Must be in the axial plane • Must have good myocardium discrimination (including good blood suppression) • TE can be optimized for your system, but should be proton density/ T1 weighted (less than approximately 45 msec). • This sequence may be from a different patient from the other sequences. • Note that single shot (e.g., "HASTE", "SSFSE" or "SSTSE") imaging technique is not acceptable. 	Must cover from aortic root to diaphragm (axial)	Slice thickness ≤ 8.0 mm Gap ≤ 4 mm In plane pixel (read) ≤ 1.6 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ²
SHORT AXIS CINE	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Real time cine images are not acceptable • Must show entire systolic cycle • Must have good myocardium discrimination (including good blood suppression) • Must image end systole and end diastole • Steady State free precession technique is preferred, but fast gradient echo is allowed 	Must cover entire left ventricle from base to apex	Slice thickness ≤ 8.0 mm In plane pixel (read) ≤ 1.6 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ² Temporal resolution ≤80 msec (without view sharing)
LONG AXIS CINE 2 Chamber	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Real time cine images are not acceptable • Must show entire systolic cycle • Must have good myocardium discrimination (including good blood suppression) • Must image end systole and end diastole • Steady State free precession technique is preferred, but fast gradient echo is allowed 	Single slice oriented vertically through the middle portion of the left atrium and the middle portion of the left ventricle	Slice thickness ≤ 8.0 mm In plane pixel (read) ≤ 1.6 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ² Temporal resolution ≤80 msec (without view sharing)
LONG AXIS CINE 4 Chamber	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Real time cine images are not acceptable • Must show entire systolic cycle • Must have good myocardium discrimination (including good blood suppression) • Must image end systole and end diastole • Steady State free precession technique is preferred, but fast gradient echo is allowed 	Single slice oriented vertically through the middle portion of the left atrium and the middle portion of the left ventricle	Slice thickness ≤ 8.0 mm In plane pixel (read) ≤ 1.6 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ² Temporal resolution ≤80 msec (without view sharing)

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<p>LONG AXIS CINE Aortic Outflow Tract</p>	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Real time cine images are not acceptable • Must show entire systolic cycle • Must have good myocardium discrimination (including good blood suppression) • Must image end systole and end diastole • Steady State free precession technique is preferred, but fast gradient echo is allowed 	<p>Single slice oriented vertically through the middle portion of the left atrium and the middle portion of the left ventricle</p>	<p>Slice thickness ≤ 8.0 mm In plane pixel (read) ≤ 1.6 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm² Temporal resolution ≤ 80 msec (without view sharing)</p>
<p>DELAYED GADOLINIUM ENHANCED</p>	<ul style="list-style-type: none"> • Must be gated to the cardiac cycle • Must have no significant arrhythmia during the MRI cardiac cycle • Must be in the short axis plane in patients with prior myocardial infarction • Inversion prepared gradient echo pulse sequence • Must choose TI so that there is good suppression of normal myocardium • Must show sufficient contrast between normal myocardium and scar 	<p>Must cover entire left ventricle from base to apex in the short axis</p>	<p>Slice thickness ≤ 10.0 mm Gap ≤ 2.0 mm In plane pixel (read) ≤ 1.9 mm In plane pixel (phase) ≤ 3.1 mm Pixel area ≤ 5.9 mm²</p>