KNEE MRI 1.5T

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1. Introduction

1.1 Background and rationale

MOST is a multicenter, longitudinal, prospective observational cohort study of risk factors for the development and progression of knee osteoarthritis (OA) and knee pain. This is a nationwide research study sponsored by the National Institute on Aging and coordinated by the San Francisco Coordinating Center. An existing cohort of 1500 men and women now aged 60+ have now been followed for 10 years. These participants along with a new cohort of 1500 younger men and women are currently being followed to help investigators better understand how to prevent and treat knee osteoarthritis, one of the most common causes of disability in adults. 1.5T Extremity Scanner MRI images of participants' knees are being acquired to examine structural features related to knee osteoarthritis.

1.2 Purpose of the manual (1.5T MRI)

This manual is intended for the MRI technologists, principal investigators, and study coordinators at the clinical centers. The purpose of this manual is to standardize the imaging techniques and administrative procedures related to the MRI component of the MOST for evaluating participants with OA of the knee. The manual describes the MRI techniques to be used along with the procedures for documentation and transfer of the MRI data to the Coordinating Center at the University of California, San Francisco (UCSF).

The role of the UCSF Coordinating Center will be to:

- train and certify the clinic GE Optima MR430s 1.5T MRI technologists
- monitor the performance of the MRI technologists throughout the study
- check all GE Optima MR430s 1.5T MRI scans for completeness, protocol adherence, and quality as soon as possible after they arrive at the UCSF Coordinating Center
- provide immediate feedback to the MRI technologists when quality and protocol problems are detected
- request repeat MRI scans as needed to correct problems
- inventory and archive all MRI scans
- provide bimonthly (every other month) Quality Assurance reports to the UCSF Coordinating Center and the MOST investigators on scans received, quality issues, and scans read in the previous month
- work with site MRI technologists and Pro Imaging Services (San Diego, CA) to evaluate scanner performance and need for maintenance and service during the study
- organize the MRI scans for reading
- read the MRI scans using the WORMS methods

1.3 Design of MRI study component

The MR component of the MOST comprises bilateral imaging, using the GE Optima MR430s 1.5T scanner, of the knee joints in 2700 participants (about 90% of the study population) who do not have contraindications for the MR examination (see Section 3.1).

Bilateral knee MR imaging has been performed at the baseline, 30-months, 60 months, and 84 months visits on participants of the existing cohort who did not have contraindications for the MR examination. Those participants are now returning for imaging at 140 month and 164 month follow-up visits. Participants of the new cohort will have bilateral knee MR imaging at the 140 month and 164 month visits.

These MRIs will be performed using a 1.5T dedicated system (GE Optima MR430s) with a circumferential extremity coil. Imaging procedures will include axial, sagittal, and coronal FSE with SmartFat sequences on both knees. The total imaging acquisition time required for MRI of both knees including participant set-up will be approximately 60 minutes (30 minutes for one knee).

1.4 Training of MRI technologists

Each clinic will hire one or more dedicated MRI technologists to perform scans on the GE Optima MR430s 1.5T scanner. This person must successfully complete the training provided by the contracted services company, Pro Imaging Services (San Diego, CA).

A representative from the UCSF Coordinating Center will travel to the study clinic to further train and certify the technologists in the MOST procedures. The MRI QA and Reading Center will certify trained technologists in the MOST protocol. Certification will be based on the results of the training session and a review of 10 volunteer/participant knee scans. Appendix 2 shows the certification form.

Only designated and certified technologists should perform the MOST examinations. A unique MOST staff ID number will identify each technologist involved in the study.

2. Equipment and supplies

The GE Optima MR430s is a Magnetic Resonance Imaging (MRI) system designed specifically for imaging the human extremities (knees will be imaged in MOST). GE Healthcare manufactures the 1.5Tesla MRI scanner. The GE Optima MR430s Guides (GE ONI Legacy-MSKExtreme1.5TAA500 Documents DOC0934737, DOC0933241, DOC0933241, DOC0798902, and ONI MSK Extreme 1.5T Operator User Guide part #5000-4700-001), should be referenced for information about the equipment and software operation.

2.1 Service and maintenance

The GE Optima MR430s is a complicated medical imaging device and must be maintained by Pro Imaging Services trained service personnel. The system requires preventive maintenance four times annually. Warranty and onsite service and preventive maintenance are specified in the sales agreement. Each clinical center is responsible for equipment service requests and preventive maintenance.

3. Safety issues and exclusions

Screening is required for all participants to determine if the participant is at risk of injury from the MRI exam. For safety reasons, participants will be screened for contraindications and hazards. The MRI technologist must thoroughly understand specific contraindications and hazards for the GE Optima MR430s system (GE ONI Legacy-MSKExtreme1.5TAA500 Document DOC0933218).

3.1 MRI contraindications

The following are contraindications for the 1.5T MRI scanner:

1. Weight greater than 350 lbs.
2. Surgery in the past two months (except surgeries/procedures on approved list - see Appendix 3)
3. Electronic implant or device, such as cochlear implant
4. Magnetically-activated implant or device, such as magnetically-activated dental implant or dentures, or magnetic eye implant
5. Heart pacemaker
6. Implanted heart defibrillator
7. Internal electrodes or wires, such as pacemaker wires or bone growth / bone fusion stimulator wires
8. Neurostimulation system, such as spinal cord stimulator or gastric electrical stimulation system
9. Surgically implanted insulin or drug pump
10. Tissue expander with magnetic port, such as inflatable breast implant with magnetic port
11. Brain aneurysm surgery, brain aneurysm clip(s) or coil(s)

The following implants/metal injuries may be MRI safe and require medical documentation showing that it is safe for the participant to have an MRI scan:

1. Stent, filter, coil or clips
2. Shunt (spinal or intraventricular)
3. Surgically implanted hearing device (not a regular hearing aid) or prosthesis in your ear
4. Eyelid spring, wire or weights
5. Penile implant or prosthesis (men only)
6. Heart valve
7. Injury in which metal fragments entered your eye and you had to seek medical attention

8. Injury by a metal object such as shrapnel, BB, or bullet

The following conditions are contraindications for a specific knee:

1. Knee replacement or knee surgery with metal implants such as pins, screws, staples, etc. (only knee with knee replacement or metal implants is not scanned)
2. Leg does not fit in the knee coil

MRI exclusion questions are asked by the MRI technologist prior to the MRI scan to determine whether the participant will be excluded from this examination. The MRI technologist needs to confirm that participant should not be excluded for safety reasons. Further MRI safety information can be found at http://www.mrisafety.com/. A copy of the Reference Manual for Magnetic Resonance Safety, Implants and Devices: 2008 Edition should be located in the MRI suite (refer to the MOST Equipment List on the MOST website for ordering information), or the online website at http://www.mrisafety.com/list_search.asp can be used to search for safety information about particular implants/devices.

4. Participant and exam room preparation

If possible, the MRI exam should be scheduled prior to or one hour after the participant's isotonic power of the knee extensor (or Quadriceps Power) exam. Proper participant set up should ensure correct positioning of the knee and sufficient participant comfort to limit motion artifacts.

4.1 Participant positioning

Positioning of the participant's knee in the gantry must be reproducible from visit to visit to allow accurate comparison of serially acquired images. **For the 164-month visit MRI, the MRI technologist should view the 140-month knee MRI scan and match the participant positioning in the knee coil as closely as possible.** If the knee is in internal or external rotation on the 140-month scans, match follow-up scans in the same degree of rotation. Generally, the participant sits in a chair with the leg in neutral position and the patella pointing straight up rather than in slight external rotation, as is commonly done in clinical imaging protocols. External rotation is more difficult to reproduce on serial exams and complicates image interpretation in this study. Additionally, the knee must be well immobilized in the circumferential extremity coil with foam padding. If possible, try to keep some space (even just a thin cotton cloth) between the knee and coil to reduce 'coil noise.'
How to properly position a participant's knee in the magnet is described in detail in the following section (for handling of the patient chair, positioning of the RF coil and handling of the laser alignment light, please refer to the GE Optima MR430s Operator's Guide as referenced):

1. Place the 180 mm diameter RF Coil into the system.
2. Place the leg rest into the retracted position.
3. Bring the chair back and chair base into the full upright position.

4. Unlock the chair and position it in the approximate position leaving a gap for participant access between the magnet and chair. Relock the chair.
5. Adjust the heel rest.
6. Seat the participant in the chair.
7. Have the participant place their foot of the leg to be imaged in the entrance of the RF coil. The other foot should be placed on the footrest on the base of the chair or on the floor.
8. Measure 250 mm from the knee to the upper leg.
9. Unlock the chair and gently roll it until the reference point is aligned with the laser alignment light.
10. Properly position the participant's heel into the heel rest and secure the heel rest.
11. Lock the chair wheels.
12. From the participant's side, insert foam wedges around the participant's leg for stability and comfort during the scan.

4.2 Participant comfort and prevention of motion artifacts

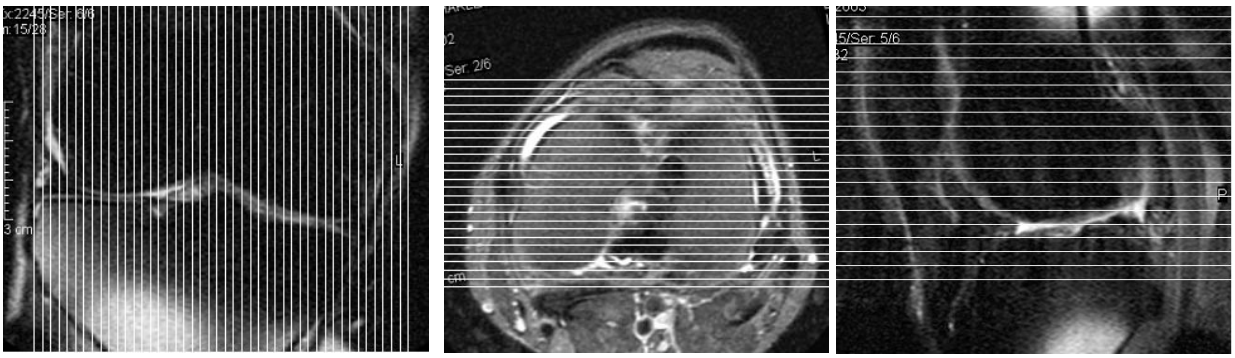
The comfortable positioning of the participant at the beginning of the examination is critical to limiting motion artifacts. Care should be taken in properly placing the cushions and pads around the knee in the extremity coil. Earplugs should be included along with pillows, blankets and verbal reassurance. The participant should be told to not move during the scan. **When the technologist sees motion during the scan, the sequence(s) should be repeated.**

5. MRI sequence protocols

5.1 Imaging planes set-up

Special care should be taken in the planning of the sequences. For follow-up scans, the MRI technologist should view the baseline MRI sequences and set-up the imaging planes exactly as was done during the baseline image acquisition. Complete anatomical coverage in each plane is very important for the reading. See examples of correct planning (Figure1). Internal/external rotation should be matched as closely as possible to baseline. Adjustments further in or out of scanner can be made at follow-up for best quality coverage and images (see MOST 1.5T MRI Atlas CD).

Figure 1: Correct planning for complete coverage of anatomy



Sagittal Plane **Coronal Plane** **Axial Plane**

5.2 Imaging parameters

All parameters for MOST should be pre-programmed into the MRI computer to limit the potential for human error. The total examination time including 10 minutes for participant set-up, is approximately 60 minutes for both knees (30 minutes for one knee).

The MR system should be checked on a weekly basis and logged in the QA log to confirm that these pre-programmed sequence parameters are in adherence with the protocol as documented below.

If sequence parameters are individually adjusted to improve image quality, please indicate the non-standard sequence and explain why on the “Comments” section of the 1.5T Knee MRI Tracking Form for the relevant knee and sequence.

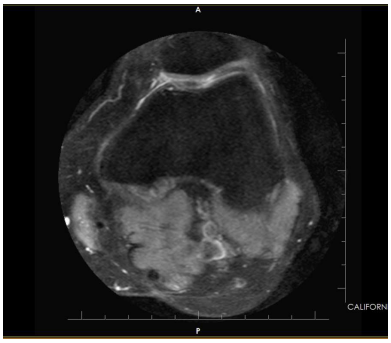
Localizer: 25 sec

Prescan: 60 sec

Reconstruction: 60 sec

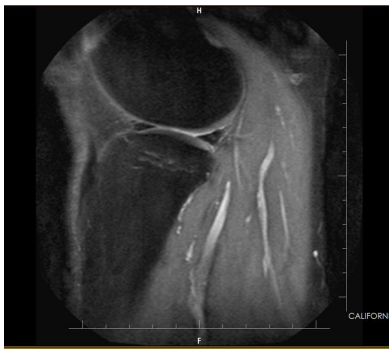
The knee may require repositioning for the second repeat localizer before the main set of sequences is performed.

1. Axial FSEfw SmartFat



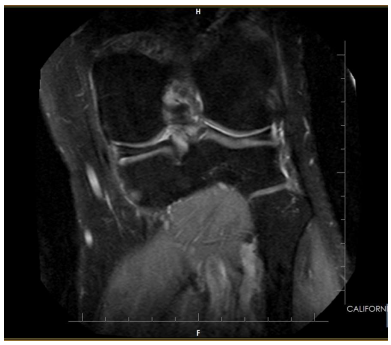
TR: 4200 msec.
TE: 11.0 msec.
Thickness: 3 mm
Gap : 0
Slices : 32
Frequency x Phase: 280 x 192
NEX : 2
Prescan: water (auto), peak (manual)
FOV: 140
Frequency direction: A/P
Echo train length: 12
Set center frequency: water (left-hand peak)
Time: 2 min 57 sec.

2. Sagittal FSEfw SmartFat



TR: 4800 msec.
TE: 11.0 msec.
Thickness: 3 mm
Gap: 0
Slices: 36
Frequency x Phase: 280 x 192
NEX: 2
Prescan: water (auto), peak (manual)
Flip angle: 90 degrees
FOV: 140 mm
Frequency direction: H/F
Echo train length: 12
Set center frequency: water (left-hand peak)
Time: 3 min 25 sec

3. Coronal FSEfw SmartFat



TR: 4500 msec.
TE: 11.0 msec.
TI: 120 msec
Thickness: 3 mm
Gap: 0
Slices: 34
Frequency x Phase: 280 x 192
NEX: 2
Prescan: water (auto), peak (manual)
Flip angle: 90 degrees
FOV: 140 mm
Frequency direction: H/F
Echo train length: 12
Set center frequency: water (left-hand peak)
Time: 3 min 05 sec

6. Detailed MRI exam instructions

Refer to the GE Optima MR430s Operators Guide for information about entering participant information and performance of a GE Optima MR430s 1.5T MRI examination.

6.1 Labeling the images

The following information should be entered into the MRI image header, by using "Patient Entry Screen" and "Scan Setup Screen" on the operator console computer, so that the information will appear on the images sent to the Coordinating Center at UCSF.

Patient Entry Screen

1. Patient ID = MOST Participant ID#
2. Patient Name = 4-letter MOST Acrostic
3. Birth Date – leave blank
4. Sex = enter gender (male or female)
5. Age = leave blank
6. Weight = enter weight (exam will not begin unless weight value is entered)
7. Operator = enter staff MOST ID#

Scan Setup Screen

Anatomy = select either Left Knee or Right Knee from the pull-down menu

6.2 Examination Procedures and Scanning Large Knees

The procedures for the examination are outlined in the GE Optima MR430s Operator's Guide and will be covered during the onsite training provided by Pro Imaging Services. Each knee will have a unique examination number.

For each of the sequences used in MOST, the MRI scanner has a predefined default value for the number of slices to be scanned (axial sequence = 32 slices, sagittal sequence = 36 slices, coronal sequence = 34 slices). When using these numbers of slices (or less) and coverage of all relevant anatomy is allowed, then the pulse sequence parameters TR specified in section 5.2 will be allowed by the scanner.

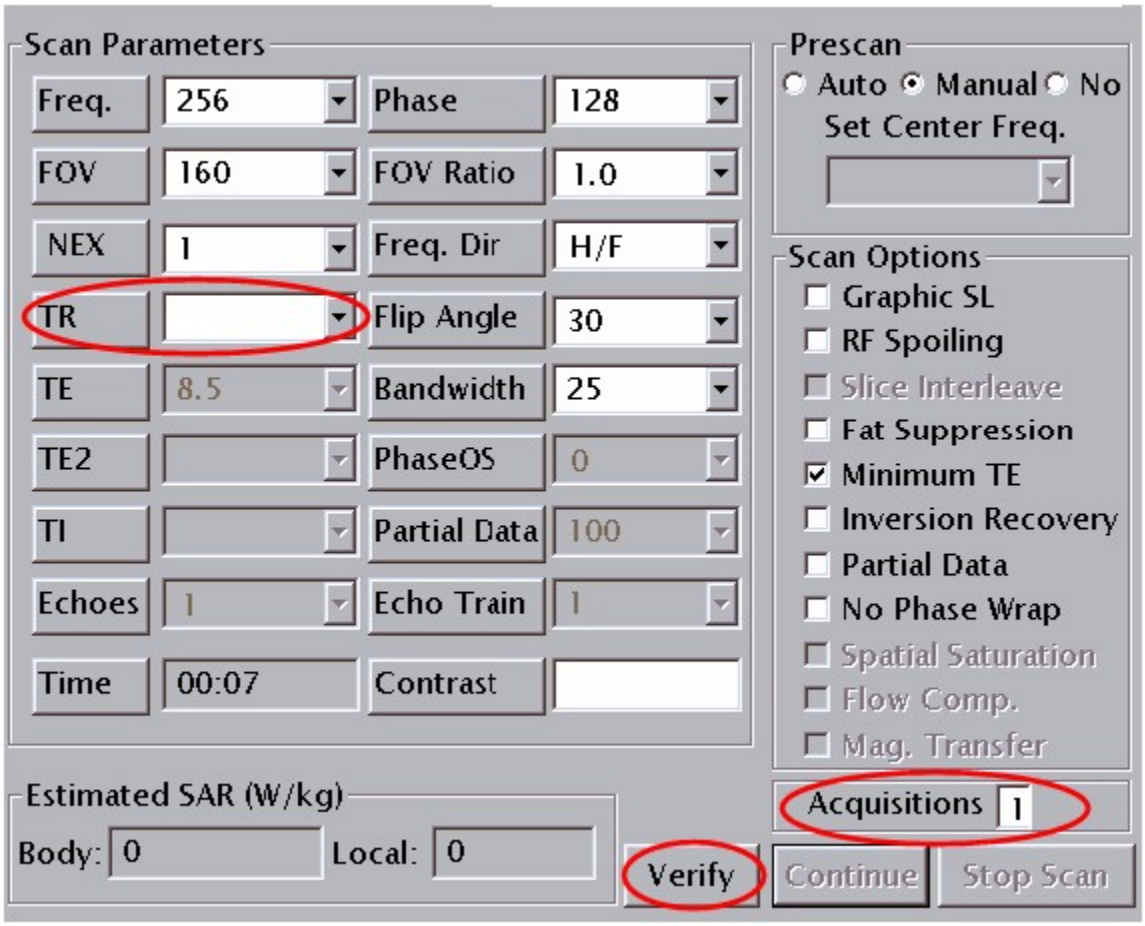
For large knees, increasing the number of slices may be required to cover the correct amount of knee anatomy. In such cases, the MRI tech needs to check whether the parameter "Acquisitions" on scanner console doubles from a value of 1 to a value of 2 which will double the scan time.

In such cases, the MRI tech needs to increase the value of TR to ensure that "Acquisitions" returns to a value of 1. To do this, click the left mouse button over the 

button on the scanner display to see what "parameter hint" the scanner gives. The scanner will report the minimum value that TR has to be for "Acquisitions=1". TR needs increasing to slightly above that value. The GE Optima MR430s Operators Guide describes how to use "parameter hints".

So for large knees, increase the value of TR to be slightly higher than the minimum value shown by the "parameter hint" (maybe 10 or 20ms higher) and then click the "Verify" button and ensure that there are no problems. For very large knees, TR may get as large as 9000ms for the coronal sequence and sagittal sequence and for the axial sequence values approaching 6000ms might be required.

The following figure shows the relevant parts of the scanner display which will need to be used during this procedure.



IMPORTANT: Never scan a knee when the value for Acquisitions is 2 – ALWAYS keep increasing TR followed by clicking Verify until Acquisitions=1 is allowed.

6.3 Completing the 1.5T Knee MRI Tracking Form

Data is recorded on the data collection form. Refer to MOST Data Management operations manual for instructions in completing the forms.

- The MOST ID# and Acrostic will be pre-filled on the form, but must be verified by matching the ID badge the participant is wearing and the ID, ACROSTIC and name in the participant's study chart before the MRI is completed.
- If you do not obtain a good quality MRI exam (including all required sequences), please use Question #5 to indicate why.

6.4 QA checks of MRI images by MRI technologist

The MRI technologist is responsible for ensuring that the quality of the examination and images is evaluated *before* the participant is released from the examining room. Poor quality images (those that exhibit any of the quality problems described below) should be repeated. If the image cannot be improved, the reason should be stated in the "Comments" field on the 1.5T MRI Knee Tracking form. Please detail any participant or equipment issues, e.g. large knee/thigh or knee pain/participant cannot stay still.

Each participant's scans should be checked for:

1. Completeness

   Were all of the sequences done during the baseline MRI scan acquired? If not, record why sequences were not obtained using Question #5 of the 1.5T Knee MRI Tracking Form.

2. Protocol adherence

   The data has been acquired using the correct MRI parameters in strict accordance to this MRI manual (see section 5). At the beginning of each week the MRI technologist should check the sequence parameters and make sure those programmed on the MR system matched those on the protocol. In some cases, the exact MRI parameters cannot be achieved for one reason or another, e.g., the TR or field of view may have to be increased slightly for an unusually large knee to achieve full anatomical coverage. Please indicate non-standard sequence and explain why on the "comments" section of the Knee MRI Tracking Form.

3. Image quality

   Images should be checked at the time of the exam by the MRI technologist for possible problems listed below before the participant is released or the images are written to the DICOM server. Images that do not meet these quality criteria should be reacquired. If the problem cannot be resolved with reacquisition, record the reason for the problem using Question #5 on the 1.5T Knee MRI Tracking Form for each sequence and knee (right/left) affected.

   - **Incomplete coverage of anatomy**
     Complete coverage of anatomy in all planes is very important as otherwise the examination will be incomplete and the scans might not useful for radiologist reading. See Section 5.1 (Figure 1) for examples of correct planning. If anatomy is insufficiently covered, the sequence should be repeated. If the baseline scan had incomplete coverage, the technologist should try to get more complete anatomical coverage during follow-up. Meniscus and/or tibia artifact should be avoided with complete tibia coverage in the sagittal sequence.

- **Motion artifacts**
  Positioning the participant comfortably using cushions and pads around the knee, and emphasizing the importance of lying still can minimize participant motion artifacts (refer to Section 4.1). Images degraded by participant motion artifacts should be repeated after correcting any causes of participant discomfort or anxiety. Often verbal reassurance is sufficient to allay mild participant anxiety. However, physical limitations or severe claustrophobia may require that the participant not complete the MRI exam.

- **SmartFat saturation failure or omission**
  Frequency-selective SmartFat saturation must be used in the fast spin echo sequences. It eliminates chemical shift artifacts along cartilage margins and is essential for detecting bone marrow edema. Fat saturation failure can occur in areas of irregularly shaped anatomy, such as the patella. Usually, this artifact does not extend to the patellar cartilage, but it can interfere with assessment of patellar marrow edema. Accidental omission of the frequency-selective fat saturation pulse is a significant oversight. If frequency-selective fat suppression was incidentally not applied, the sequence should be repeated. If incomplete fat saturation occurs, the FOV should be optimized. Complete coverage of the tibia will limit the partial fat saturation failure artifact in the sagittal sequence.

- **Susceptibility artifacts/metallic artifacts**
  Since ferromagnetic materials typically have large susceptibilities, field distortions and artifacts are prominent around implanted metal objects. As participants with prior knee surgery will be included in the study, metallic artifacts may occur at MR imaging. These artifacts cannot be avoided. These images should be sent to the MRI QA and Reading Center in the usual way, with the problem noted on the 1.5T Knee MRI Tracking Form . The MRI QA staff will determine whether the image quality is sufficient for reading despite the artifacts.

- **Wraparound/Aliasing**
  The use of “No-Phase-Wrap” software should avoid aliasing. Increasing the FOV to encompass the entire anatomic dimension of the knee in the affected direction will also help to eliminate aliasing. As an alternative strategy, the frequency and phase-encoding axis may be swapped so that the shorter dimension of the object (knee) is oriented in the phase-encoding direction.

- **Low SNR**
  Low signal to noise ratio (SNR) often manifests itself as images which are grainy and with low contrast between different types of tissue, and when no other problem such as motion or metallic artifacts are present.

6.5 Longitudinal QA

Regularly scheduled image-based QA tests (Daily Quality Assurance or DQA; Appendix 1) will be done to verify the proper working condition of the system (GE Optima MR430s Operator's Guide). Document the QA scan as "DQA" on the MRI Log. The oil-water phantom should be scanned weekly with the FSEfw SmartFat sequence.

6.6 Electronic transfer of images from the GE Optima MR430s scanner

After a participant has been scanned, the participant's images should be transferred electronically from the GE Optima MR430s to ConquestDICOM on the PC workstation in the scanner room, in preparation for electronic transfer to the Coordinating Center.

This is done using the "Archive" button on the top right of the main display on the GE Optima MR430s scanner and using the "Transfer" option to perform a DICOM image transfer to the ConquestDICOM workstation.

6.7 Setting up secure DICOM image transfers

A secure data transfer link to the Coordinating Center for DICOM image transfers will be set up to automatically and securely transfer images received by ConquestDICOM to the Coordinating Center using secure FTP. See the Operations Manual for Secure Data Transfer for more information.

6.8 Electronic transfer of images to the Coordinating Center

The MRI technologist is responsible for ensuring the correct completion of the 1.5T MRI exams *after each participant is scanned and before the images are transferred to the Coordinating Center*.

Once the transfer from the GE Optima MR430s scanner to the Conquest DICOM workstation has completed, the secure DICOM image transfer process to the Coordinating Center should start automatically. Automatically running software forwards the images over a secure and encrypted connection to the Coordinating Center.

The MRI Missing Information reports on the MOST study website (http://keeptrack.ucsf.edu) should be regularly checked. These reports are clinic-specific and will list any MOST participants for which the UCSF Coordinating Center does not have MRI scans yet. If scans have been listed as missing for more than 2 working days, please contact the UCSF Coordinating Center via e-mail.

The UCSF Coordinating Center will contact the relevant clinic via e-mail if there are any incomplete or missing MRI image transfers. The usual solution is to re-transfer any images from the MRI scanner to Conquest DICOM. Images that are older than 14 days can be deleted from the scanner as long as the image is not listed on the MRI Missing Information report

7. Image QA at the UCSF Coordinating Center

7.1 QA review of participant images

Upon receiving the images, the UCSF Coordinating Center will check the images to confirm that all PHI/PII has been removed. This includes reviewing the DICOM headers.

In addition, the UCSF Coordinating Center will check the images to ensure that all sequences in the protocol were included and that the pulse parameters used were in agreement with the protocol. The images will also be checked for adequate anatomical coverage and the presence of artifacts.

The MOST MRI QA center staff will send the repeat and/or resend requests for MRI scans to the clinical sites as a MOST numbered memo every 2 weeks. Repeat examinations should be performed as soon as possible.

If problems with image quality or protocol adherence are encountered, the UCSF Coordinating Center will work directly with the clinical site to correct the problem.

Request for repeat scans, in the event that the initial scan is unusable or missing, will be sent as a MOST numbered memo. While it is important to have usable scans on all eligible participants, we realize that practical considerations may make it difficult for some participants to return for a repeat MRI. Therefore, it will be left up to the clinical and professional judgment of the study

coordinator and onsite investigator to decide whether to re-contact the participant. If a participant is not re-contacted or refuses to undergo a repeat MRI, the study coordinator must notify the MRI QA and Reading Center, so that this can be noted in the database comments field, and the repeat request cancelled.

7.2 QA Review of daily phantom scans

During the first several weeks of the study, the UCSF Coordinating Center perform QA of the daily phantom scans as soon as the scans are received. Thereafter, QA of the phantom scans is done on a weekly basis.

8. Questions and contact information

Removed for public release

Appendix 1 Daily Quality Assurance Procedures

ONI Memorandum

TO:	MOST Study Staff
FROM:	Jon Trudeau, Xiaole Hong, Pete Roemer
SUBJECT:	System Daily Quality Assurance Testing
DATE:	03/21/2003
CC:	Bob Kwolyk, Mike Balistreri

Purpose

The following is a recommendation from ONI Inc. for tests to be run on the OrthOne MRI system to ensure proper operation during the MOST study. This recommendation is related to ongoing testing as opposed to the tests to be run prior to initial system turnover. It is not ONI's intent to impose specific tests but rather make recommendations for consideration by the MOST study investigations.

The tests described below are recommended based on the importance of maintaining the highest possible fat suppression volume. A summary of the tests described is:

1. Monitor and maintain magnet room temperature. Large changes in room temperature affects shim as noted below.
2. Run top-level signal-to-noise tests on all RF coils being used.
3. Monitor the fat suppression volume on an Oil/Water phantom using the 3D Dixon Sequence.
4. Monitor the fat suppression volume on an Oil/Water phantom using a frequency selective Fast Spin Echo sequence.

Over time the amount of testing may be reduced. For example, it may be perfectly acceptable to use the human images en lieu of the images of the Oil/Water Phantom.

Attached is an example data sheet for recording information. Some pass-fail criteria remain asTBD (To Be Determined) and should be adjusted based on initial experience with the system.

Room Temperature

Due to the nature of the Magnet design and the use of passive shimming, the magnet homogeneity can vary with room temperature. It is therefore important to maintain temperature stability of the magnet room in order to maintain the largest possible fat suppression volume for frequency selective suppression methods. Inversion Recovery and the 3D Dixon sequence are not sensitive to small variations in shim.

ONI's recommendation is the maintenance of the magnet room temperature to 3 degrees Celsius or better if feasible. Given the importance of the temperature, it is also recommended that the temperature be recorded for trending analysis.

Imaging Tests

The following tests should run by the MRI technologist at the beginning of each day. These tests should be run under a single exam so the results may be backed-up and viewed at a later date for reference. Sample test data sheets are provided.

- *180mm RF Coil SNR:* This test verifies the proper operation of the system as a whole in addition to verifying the proper operation of the 180mm RF coil.
    1. Run the procedure outlined in the 'Running the Daily QA Test' section of the Operator's Guide.
    2. In the resulting image (viewed from the 2D Viewer or Scan Display), a summary line will be displayed (refer to Figure 1). Record the following values:
        - » Test results (pass/fail)
        - » Receiver Gain (RXG)
        - » Transmitter Gain (TXG)
        - » Signal Mean (IS)
        - » Signal-to-Noise Ratio (SNR)
        - » Artifact-to-Noise Ratio (ASR)
- *123mm RF Coil SNR:* This test verifies proper operation of the 123mm RF coil. ***It should be run only on days when the 123mm RF coil will be used.***
    1. Run the procedure outlined in the 'Running the Daily QA Test' section of the Operator's Guide except use the 123mm RF coil and change the following scan parameters in the Daily QA sequence: Thickness=3.5 (keep number of slices = 1), Freq=512, Bandwidth=50. Record the values of Receive Gain (RG) and Transmit Gain (TG) set by Automatic Prescan (use the manual prescan window).
    2. When the acquisition is complete (it will report that the test failed due to the wrong coil being used), bring up the image in Scan Display.
    3. Record/calculate the following values:
        - » Receiver Gain
        - » Transmitter Gain
        - » Mean of center ROI (A)
        - » Average of Stdv of right and left ROIs (B)
        - » Average of Stdv of top and bottom ROIs (C)
        - » Signal-to-Noise Ratio (A/B)
        - » Artifact-to-Noise Ratio (C-B)/A

    As an example, from Figure 1, A=577.4, B=(4.4+4.2)/2=4.3, C=(4.5+4.4)/2=4.45, SNR=577.4/4.3=134.3, ASR=(4.45-4.3)/577.4=0.03%.

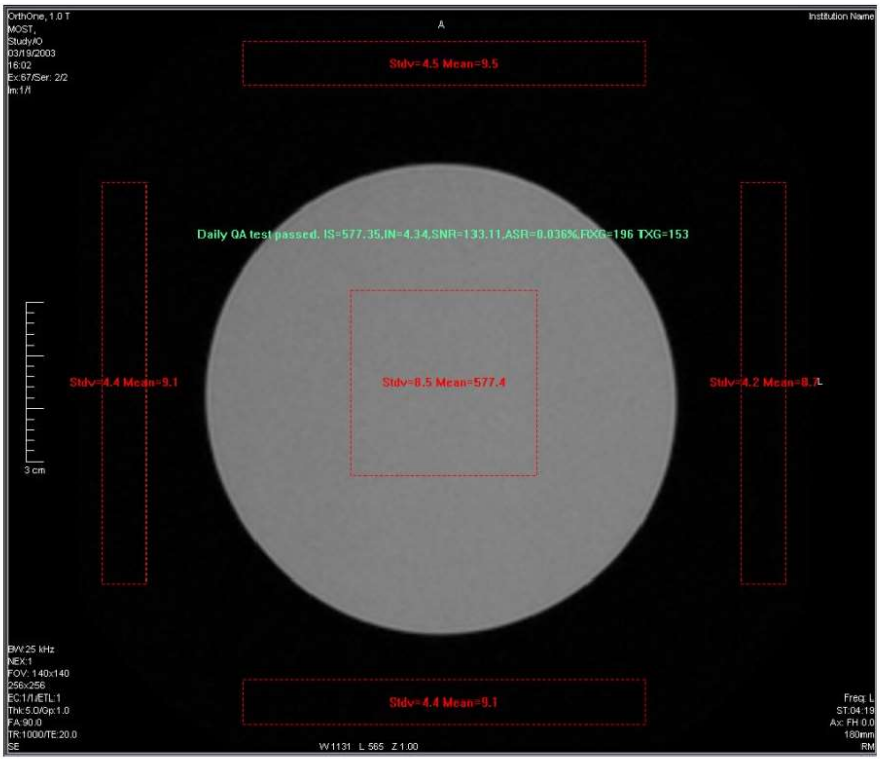


Figure 1: Example of SNR image in Scan Display using the 180mm RF coil

- *3-point Dixon Fat Separation:* This test verifies the proper operation of the system (shim, RF, etc.) as it relates to the Dixon sequence.
    1. With the 180mm RF coil in the magnet bore, place the Oil/Water phantom into the DQA foam holder and place the phantom in the RF coil.
    2. Using a sagittal single slice spin echo sequence with Freq Dir set to H/F and FOV=160, set the center frequency using the Center Frequency Fine mode of the Manual Prescan page.
    3. Run Receive Gain mode and move the phantom along the direction of the bore until the object projection is centered in the field of view (refer to Figure 2).

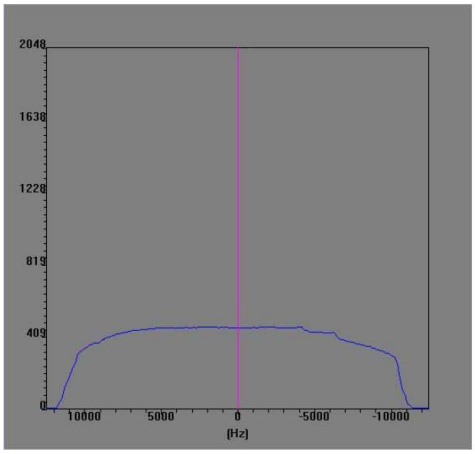


Figure 2: *Example of the projection of a sagittal slice when the Oil/Water phantom is centered*

4. Run the Gradient Shim function.
5. Exit the Manual Prescan window, select and run the sagittal Dixon sequence after reducing the number of slices to 20.
6. In slice number 11, draw a 10cm long ROI using the ROI tool in the water part of the phantom (refer to Figure 3).
7. Record the Mean (Av) of the ROI.
8. Calculate and record the intensity uniformity (1 – [Mx – Mn] / [Mx + Mn]).
9. Draw an ROI using the ROI tool in the oil part of the phantom (refer to Figure 3).
10. Record the Mean (Av) of this ROI.
11. Calculate and record the ratio of the mean of the oil signal divided by the mean of the water signal.

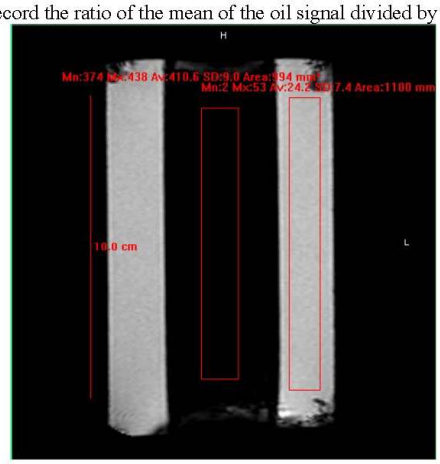


Figure 3: *Example of ROIs for the 3-point Dixon sequence test*

- *FSE with Fat Suppression:* This test gives an indication of the imaging volume in which frequency selective fat suppression will work properly.
    1. If not already placed properly, center the Oil/Water phantom in the 180mm RF coil as described above.
    2. Run the sagittal fat-suppressed FSE sequence except reduce the number of slices to 11, reduce the TR to 2000 msec, and decrease NEX to 1.
    3. Set the W/L Width value to 10 and the Level value to half of the Mean of the water signal.
    4. In slice number 6, measure and record the distance of proper fat suppression along the center of the phantom (refer to Figure 4).

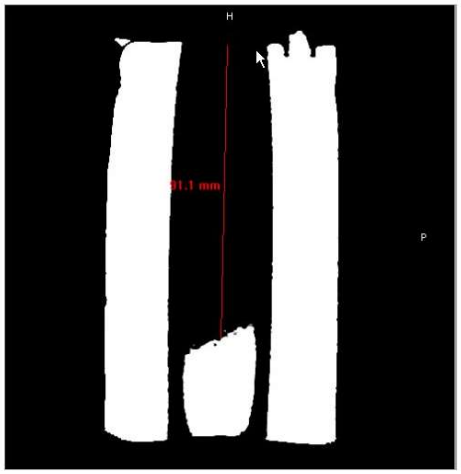


Figure 4: *Example measurement for the FSE Fat Suppression test*

Sample Daily Test Data Sheet

Site:_____ Date:_____

180mm RF Coil Test

Variable	Min	Measured	Max
Test results (pass/fail)	-		-
Signal Mean (IS)	-		-
Signal-to-Noise Ratio (SNR)	110		140
Artifact-to-Noise Ratio (ASR)	0		1%
Receiver Gain (RXG)	-		-
Transmitter Gain (TXG)	120		160

123mm RF Coil Test

Variable	Min	Measured	Max
Mean of center ROI (A)	-		-
Average on Stdv of right and left ROIs (B)	-		-
Average on Stdv of top and bottom ROIs (C)	-		-
Signal-to-Noise Ratio (A/B)	114		136
Artifact-to-Noise Ratio (C-B)/A	0		1%
Receiver Gain	-		-
Transmitter Gain	40		60

3-point Dixon Test

Variable	Min	Measured	Max
Water Signal Mean	-		-
Uniformity	TBD		-
Oil Signal Mean	-		-
Oil/Water Ratio	-		TBD

FSE Fat Suppression Test

Variable	Min	Measured	Max
Fat Suppression Distance	TBD		-

Appendix 2 1.5T Knee MRI Technologist Certification Form

This form is to be used to request GE Optima MR430s MRI technologist certification. Each technologist will receive a technologist ID for the MOST study. Be certain that each GE Optima MR430s knee MRI is obtained according to the protocol. GE Optima MR430s knee MRI's should be sent to the Coordinating Center in the usual manner. The images will be reviewed for image quality and protocol adherence by:

Felix Liu
UCSF Coordinating Center
Phone: (415) 514-6392
Email: MOST Coordinating Center

After a new technologist has completed 10 scans, please complete the following information:

1. MOST Field Center: ☐ University of Alabama ☐ University of Iowa

2. Clinic Coordinator: _____

3. Certification of an GE Optima MR430s knee MRI technologist is requested for:

Name: _____MOST Staff ID#_____

4. Date(s) MRIs were sent: _____

5. The 10 sets of Optima MR430s knee MRIs submitted to the Coordinating Center for certification are:

	Participant ID	**Knee MRI Date**
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

6. Clinic Coordinator signature:_____ Date _____

This section to be completed by the Reading Center:

1. Date Request Received: _____

2. Action Recommended:
   Pass without comment: _____
   Pass with comment: _____
   Fail: resubmit _____

3. Comments:_____

4. Signature of certifier: _____ Date_____

Appendix 3 MRI-Safe Surgeries

MRI Safety: Surgeries on this list do <u>not</u> require a 2-month wait period:

- adhesion destruction or manipulation (nonsurgical)
- biopsy without surgical incision
- cyst removal with needle
- dental bridgework
- dental fillings
- destruction of kidney, bladder, or urethral stones by forced ultrasound energy
- dilation and curettage (D&C) not for terminating pregnancy and not following delivery
- injections:
  - injection of anesthetic into peripheral nerve
  - injection of anesthetic into spine
  - injection of non-anesthetic into spine
- joint or ligament injection
- insertion of catheter for intravenous fluids into vein (not indwelling catheter)
- non-metallic foreign body removal (such as glass)
- periodontal surgery
- radial keratotomy
- rubber-banding of hemorrhoids
- skin biopsy / skin cancer removal
- spinal tap without implant
- suturing of a superficial cut
- wart removal