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PROCEDURE MANUAL FOR MROS

VISIT 4 HR-PQCT EXAMS:

CROSS-CALIBRATION PHANTOM SCANS

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UCSF

Protocol v0.2

08-MAY-2016

Department of Radiology & Biomedical Imaging

1 Introduction

A critical component for verifying the comparability of MrOS participant scans across multiple imaging centers is accomplished by imaging several sets of phantoms: A) Each clinical centers' local QC phantom; B) a matching cross-calibration QC density phantom that is circulated to each site; C) a MTF/SSP resolution phantom; and D) a set of structure and composition realistic bone phantoms. The cross-calibration density phantom is analogous to the QC phantom provided by Scanco with the scanner. The purpose of this phantom is to provide a common density calibration between sites. The resolution phantom is designed to evaluate spatial resolution across the field of view and in off axis planes. Finally the structure phantoms are designed to provide stable reference datasets for longitudinal and inter-scanner comparisons of morphometric, densitometric, and biomechanical measurements for realistic 3D geometries.

2 Phantom Descriptions

2.1 Cross-calibration QC Phantom

The cross-calibration QC phantom (Figure 2-1) is identical to the standard Scanco QC phantom used at all sites for density calibration and routine monitoring of system stability. This phantom will be scanned at a fixed location to cross calibrate density-attenuation relations between scan sites.

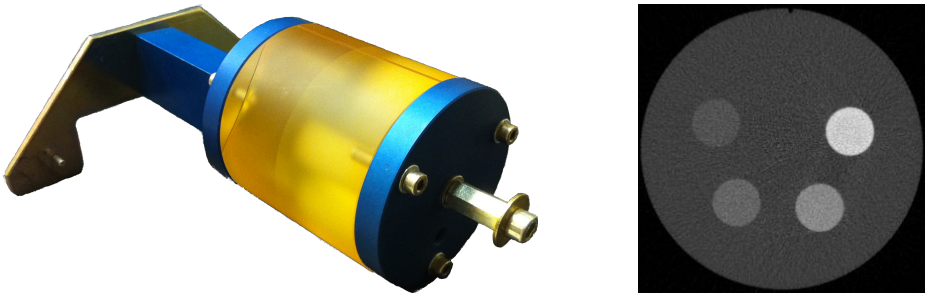

Figure 2-1: Scanco XtremeCT QC phantom

2.2 Resolution Phantom

The resolution phantom consists two sections: one to model the in-plane point spread function (PSF), and a second for measuring out of plane resolution (Figure 2-2). It consists of a 80mm diameter resin cylinder with five 25µm tungsten wires embedded parallel to the long axis of the phantom. In the first 80mm section (PSF), one wire is centered and four wires are located 30mm from center, in 90-degree increments. In the second 80mm section (SSP), a 1mm × 1mm × 25µm gold foil is centrally located.

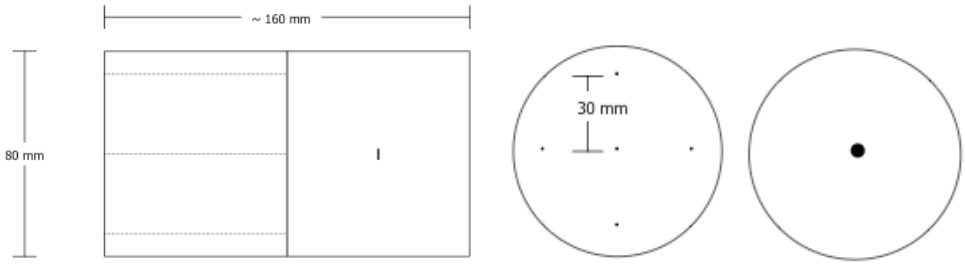

Figure 2-2: Schematic drawing of resolution phantom

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2.3 UCSF Extremity Bone Structure (EBS) Phantoms

The EBS phantoms designed and manufactured by UCSF (Figure 2-3) consist of a series of polyethylene-resin cylinders with embedded human tibia and radius sections. The bone sections are approximately 1cm thick and were extracted at an anatomical site consistent with the standard XtremeCT clinical acquisition protocol (9.5mm and 22.5 mm proximal from the distal endplates for the radius and tibia respectively). The tissue was acquired from a non-profit, NIH-funded American tissue bank (NDRI). Each tissue specimen tested negative in serological screening for common blood-borne pathogens (HIV, Hepatitis, tuberculosis, etc). The specimens were fixed in 100% ethanol prior to embedment and therefore pose no biological risk.

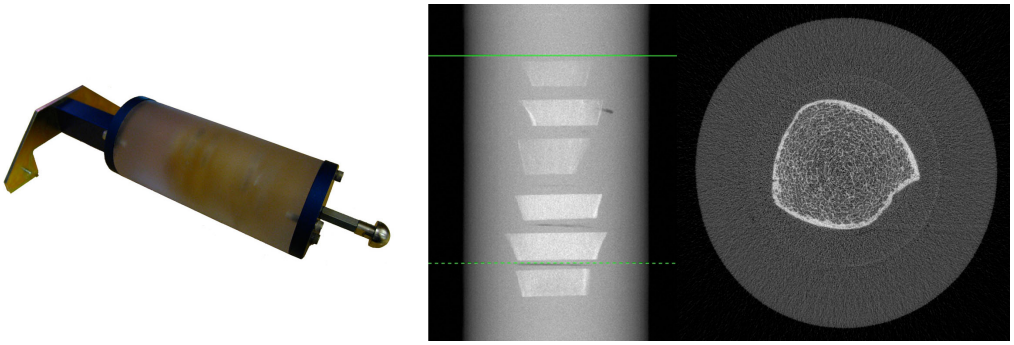

Figure 2-3: UCSF structure phantom for cross-calibration

3 Scan Protocol

NOTE: For each measurement described below record the **measurement number** in table A.2 of Appendix A

3.1 Local Daily QC scans (QC1 – Daily)

First, follow the local protocol for daily QC assessment. Coordinate with the local technical staff to verify their procedure and that the QC values are within the normal range (< 1% difference from the current calibration). In the tomography program select the sample number for the Daily QC scan (usually sample 1). Select the corresponding controlfile ("QC1 (Daily)") and perform the scan procedure a total of 3 times:

- Select the sample number corresponding to the daily QC scans (usually sample 1)
- Select the "QC1 (Daily)" controlfile
- Pre-calibrate
- Scan
- Repeat the pre-calibration and scan two more times for a total to three standard QC scans.

3.2 Cross-calibration QC phantom scans

The cross-calibration density phantom will be scanned at a fixed location to cross calibrate density-attenuation relations between scan sites. This will require a unique Sample ID in the database (i.e. do not use the standard Sample Number for the local QC1-Daily scans) as well as a custom controlfile similar to, but not identical to the QC1-Daily controlfile.

Create a new sample name/number for the scanning of the cross-calibration QC phantom. Complete the subject biographical information according to the procedures below:

3.2.1 Perform QC phantom scans

As the geometry of each XtremeCT scanner is slightly different the start position for the QC phantom needs to be determined at each site. In order to ensure the same region is scanned at all sites, the reference line will be placed at the junction of the metal endplate of the fixture and the resin cylinder. The acquisition will be made at a fixed offset configured into the controlfile that is setup during the baseline phantom scan visit. The QC phantom scan in this section will be repeated 3 times to determine an average calibration. This procedure will subsequently be repeated at a later point to account for drift during the course of the scan session. In the tomography program perform the following steps:

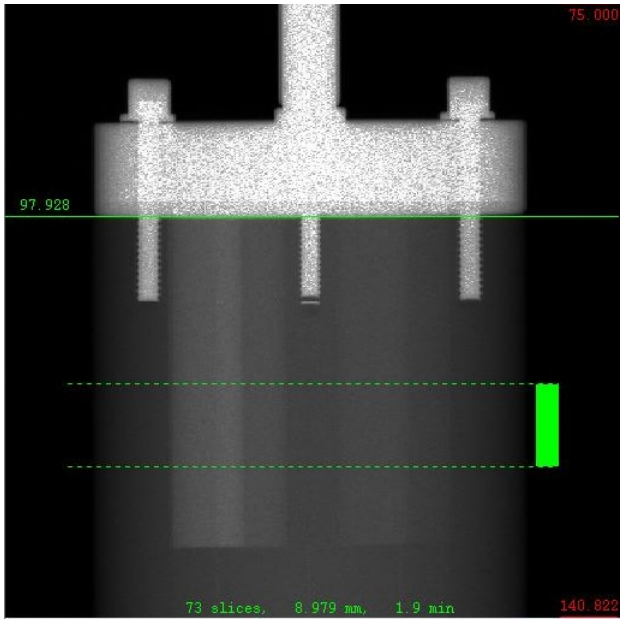

Figure 3-2: Scout View of QC phantom showing reference line placement

- Mount the cross-calib QC phantom in the scanner
- In the Tomography program select "Other…" and type "UCSF" (all caps) to locate the list of UCSF phantom sample IDs that were created during the baseline phantom scan visit
- Select "UCSF-QC1" from the list to load that ID into the scan program
- Select the "UCSF-QC1" controlfile created during the baseline phantom scan visit
- Perform a "Pre-calibration"
- Perform a scout view using the default settings (125 to 175 mm at 90 degrees)
- Select reference line and position such that the reference line is located at the junction of the metal endplate and resin cylinder (Figure 3-2)
- Select "OK" then "Scan…" and "Start Measurement" to run the scan
- Repeat the Pre-calibration, scout view, and scan two more times for a total to three scans using the same reference line position for each scan

3.3 Resolution Phantom Scans

The PSF/SSP resolution phantom will be scanned at two fixed locations. This also requires a unique Sample ID in the database and a custom controlfile that were setup during the baseline phantom scan visit.

3.3.1 Perform resolution phantom scans

As the geometry of each XtremeCT scanner is slightly different the start position for the resolution phantom scan needs to be determined at each site. In order to ensure the same region is scanned at all sites, the reference line will be placed at the junction of the metal endplate of the fixture and the resin cylinder for the tungsten wire PSF scan and placed at the mid-length notch for the gold foil SSP scan. The acquisition will be made at a fixed offset configured into the controlfile during the baseline phantom scan visit. The offsets are identical for the PSF and SSP scan. In the tomography program perform the following steps:

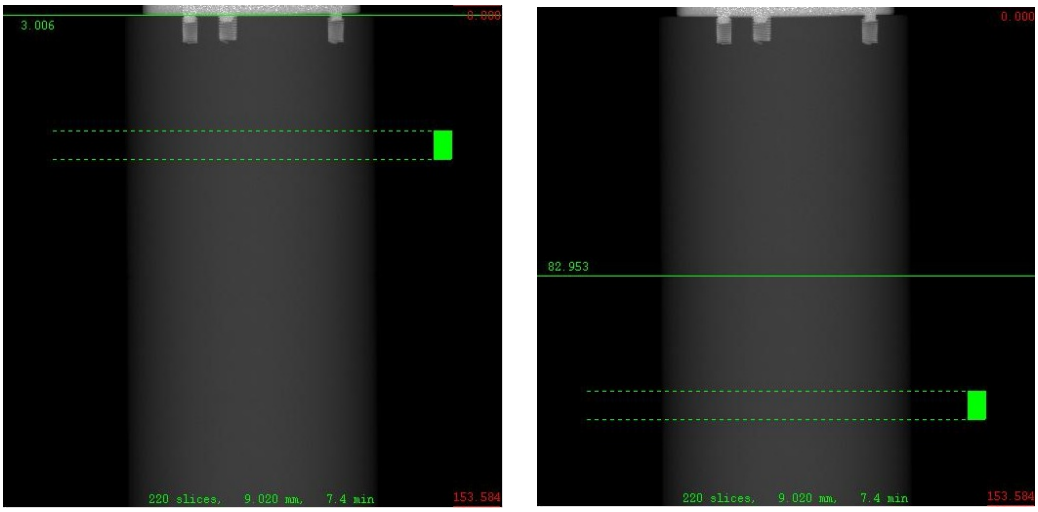

Figure 3-4: Scout Views of resolution phantom showing reference line placement for MTF (left) and SSP (right) scans

- Attach the removable fixture pieces to the resolution phantom assuring that the end with the circular stickers is attached to the double hitch mounting fixture, while the opposite side is attached to the single hitch mounting fixture
- In the Tomography program select "Other…" and type "UCSF" (all caps) to locate the list of UCSF phantom sample IDs that were created during the baseline phantom scan visit
- Select "UCSF-RP" from the list to load that ID into the scan program
- Perform a "Pre-calibration"
    - **NOTE:** It is critical that pre-calibration for the RP be performed with the phantom NOT inside the scanner. Only the QC1 phantoms can be pre-calibrated while the phantom is positioned inside the scanner.
- Select the sample name/number corresponding to the resolution phantom ("UCSF-RP") during the initial phantom scan visit.
- Select the "UCSF-RP" controlfile created during the initial phantom scan visit
- Perform a scout view using the default settings (25 to 200 mm at 90 degrees)
- Select reference line and position such that the reference line is located at the junction of the metal endplate and resin cylinder (Figure 3-4)
- Select "OK" then "Scan…" and "Start Measurement" to run the first RP scan
- Repeat the scout view using the default settings (25 to 200 mm at 90 degrees)

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- Select reference line and position such that the reference line is located in the middle of the visible notch located at the mid-length of the resin cylinder (Figure 3-4)
- Select "OK" then "Scan…" and "Start Measurement" to run the scan

3.4 EBS Phantom Scans

3.4.1 Perform EBS phantom scans

As the geometry of each XtremeCT scanner is slightly different the start position for each structure phantom scan needs to be determined at each site. Exact positioning of the scan region is not critical as long as all bone sections are included. In the tomography program perform the following steps:

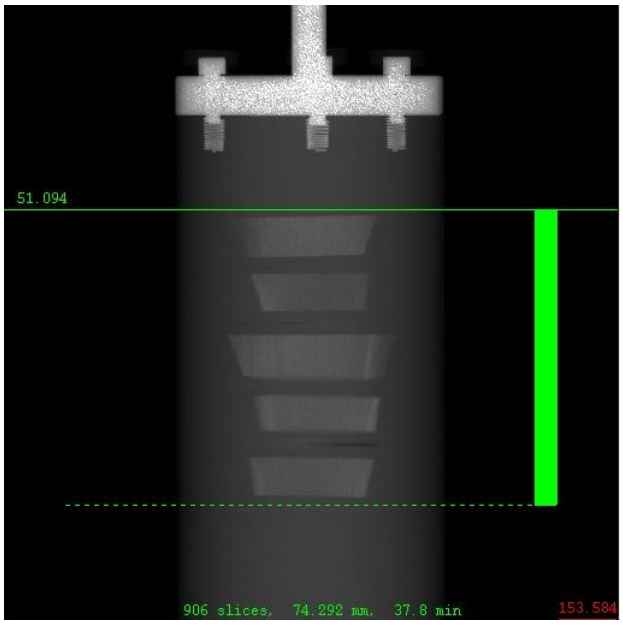

Figure 3-6: Scout view for structure phantom (82µm)

- In the Tomography program select "Other…" and type "UCSF" (all caps) to locate the list of UCSF phantom sample IDs that were created during the baseline phantom scan visit
- Select the ID corresponding to the SP phantom to be scanned (start with UCSF-SP-02) to load that ID into the scan program
- Select the "UCSF-SP" controlfile created during the baseline phantom scan visit
- Perform a "Pre-calibration"
    - **NOTE:** It is critical that pre-calibration for the SP phantoms be performed with the phantom NOT inside the scanner. Only the QC1 phantoms can be pre-calibrated while the phantom is positioned inside the scanner.
- Mount the corresponding structure phantom in the scanner (starting with UCSF-SP-02)
- Perform a scout view using the default settings (50 to 200 mm at 90 degrees)
- Select reference line and position such that the first slice is located approximately 2mm above the first bone section; press and hold the shift button to adjust the scan range such that the last slice is approximately 2mm below the last bone section (Figure 3-6)
- Select "OK" then "Scan…" and "Start Measurement" to run the scan

- Repeat these steps for the remaining structure phantom cylinders (UCSF-SP-03, UCSF-SP-04, UCSF-SP-05)

3.5 Repeat of QC Phantom Scans

The cross-calib QC phantom scans will now be repeated to average calibrations over additional time points. This is consistent with Scanco's protocol for XtremeCT installations and hardware service visits.

3.5.1 Local Daily QC scans (QC1 – Daily)

As in section 3.1, follow the local protocol for daily QC assessment. In the tomography program select the sample number for the Daily QC scan (usually sample 1). Select the corresponding controlfile ("QC1 (Daily)") and perform the QC scan procedure a total of 3 times:

- Select the sample number corresponding to the daily QC scans (usually sample 1)
- Select the "QC1 Daily" controlfile
- Pre-calibrate
- Scan
- Repeat the pre-calibration and scan two more times for a total to three standard QC scans.

3.5.2 Cross-calibration QC phantom scans

In section 3.2 the sample entry and controlfile for these scans were created and will be used for the repeat scans. Additionally it is helpful to refer to the reference line position used for the first QC phantom scans and recorded in Appendix B, though it is possible that the positioning will be slightly different.

- Mount the Cross-Calib QC Phantom in the scanner
- In the Tomography program select "Other…" and type "UCSF" (all caps) to locate the list of UCSF phantom sample IDs that were created during the baseline phantom scan visit
- Select "UCSF-QC1" from the list to load that ID into the scan program
- Select the "UCSF-QC1" controlfile created in section 3.2.2
- Perform a "Pre-calibration"
- Perform a scout view using the default settings (125 to 175 mm at 90 degrees)
- Select reference line and position such that the reference line is located at the junction of the metal endplate and resin cylinder (Figure 3-2)
- Verify that the reference line positioning is consistent with the baseline scout reference line shown in the bottom pane.
- Select "OK" then "Scan…" and "Start Measurement" to run the scan
- Repeat the Pre-calibration, scout view, and scan two more times for a total to three scans using the same reference line position for each scan

4 Data Transfer and Archiving

Unfortunately the UCSF-SP phantom scans are too large for some software components of our network transfer procedure. Therefore all raw and reconstructed image data will be transmitted to the coordinating center at UCSF via LT0 tape. Routine local backups are also to be made via the LT0 tape drive that comes with your system once transfer to the coordinating center is confirmed.

NOTE: It is important to confirm transfer to the coordinating center before RAW data are archived to local tape and removed from the system.

4.1 Data transfer to the Coordinating Center

Cross calibration phantom data will need to be copied to a LT0 tape. Please refer to the Scanco XtremeCT II User's Manual for instructions on using the tape drive to **COPY** data to tape.

NOTE: Use the "Copy-To" action in the Scanco Backup program to copy RAW and IMA data to tape. This makes a copy on tape and leaves data on disk. Be sure **NOT** to use the "Move-To" action which will remove the data from disk after it is copied to tape. "Move-To" is only to be used to perform local archiving when the data has been verified by the CC and is no longer needed on disk.

NOTE: For data transfer to the CC, separate tapes for RAW and IMA data are not necessary. You can copy both RAW and IMA to a single tape dedicated for transfer.

4.2 Local Archiving

Cross calibration phantom data should also be locally archived using the LT0 tape that was provided with the HP workstation. Please refer to the Scanco XtremeCT II User's Manual for instructions on using the tape drive for local data archiving purposes.

NOTE: RAW data, which are the raw projection images, should be archived immediately after receipt verification has been provided by the coordinating center. The raw data are no longer needed for anything, but should be preserved as a data security measure.

NOTE: IMA data, which includes the reconstructed images and all derivative files, can be kept online for a longer period of time, at the sites discretion, however operators must be sure to maintain sufficient disk space for new exams.

NOTE: Separate tapes should always be used for RAW and IMA data.

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