

QC1 Information -- MrOS QCT Library Information
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I. MrOS QCT LIBRARY

At visit 1, 3786 men were referred for quantitative computed tomography (QCT) scans. Men were referred for hip scans, lumbar scans at the L1L2 level, and abdominal scans at the L4L5 level. The hip and lumbar series were obtained so that dimensions and volumetric bone density could be measured. The abdominal scans were obtained for measurement of adipose tissue distribution and skeletal muscle. All QCT scan files were originally sent from the MrOS study site to the QCT Reading Center at the University of California, San Francisco, which was directed by Thomas Lang. Subsequently, the QCT scans were transferred to the Portland study site for creation of the QCT Library. As of December 2023, the QCT Library is at the San Francisco Coordinating Center (SFCC). All MrOS QCT scans series are in DICOM format.

This file contains information about the visit 1 scans stored in the MrOS QCT Library. The variables contained in file **QC1** indicate which scan series are available in the QCT Library. This information is provided to assist investigators who would like to use the QCT data for ancillary proposals to plan their analyses. Inquiries regarding these additional details and the use of the QCT scans for ancillary proposals should be made to the San Francisco Coordinating Center.

II. Where to find skeletal QCT measures:

Skeletal dimensions and volumetric bone density measures for the visit 1 L1L2 and hip scans are contained in files, **QS1** and **QH1**, respectively. Dr. Thomas Lang of UCSF Department of Radiology performed the image processing that produced the skeletal measures in these files.

III. Where to find abdominal body composition QCT measures:

Abdominal adipose distributions and skeletal muscle measures are contained in files, **QB1** and **QBS**. Dr. Lynn Marshall of OHSU Department of Medicine performed the image processing that produced the for abdominal body composition measures in these files.

NOTE: There is not complete agreement between the number of scans archived in the Library and the scans that produced the data for QH1 and QS1. This is because some of the CDROMS on which the files were stored deteriorated after image processing was complete at UCSF, but before transfer of the scan files to OHSU. Therefore, the **QC1 file** should be used to determine if QCT scans are stored in the MrOS QCT Library. QS1 and QH1 are not accurate with regard to the files in the MrOS QCT Library.

QCT Information, part 1.

Baseline QCT Information

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This file contains information regarding the data derived from MrOS baseline QCT scans. Topics covered include scan acquisition, scan processing, the contents of the data files, related MrOS QCT documentation, and relevant citations. *Please read this document carefully, since many notes on features of the QCT data are discussed.*

I. MrOS Baseline QCT Scan Acquisition

The baseline scans were acquired and processed under the direction of Thomas Lang, PhD, at University of California, San Francisco (UCSF) using his published methods. The MrOS study was designed such that the first 650 men and all non-White men enrolled at each site were referred for QCT scans of the hip, lumbar spine, and abdomen as part of their baseline visit. Referral of non-White men was made to enhance the statistical precision of race/ethnic comparisons. In total, 3,786 participants (63% of the MrOS cohort) underwent QCT scans. Baseline characteristics of men referred and not referred for scans were comparable, except for a slightly greater proportion of non-White men among those referred (*see Marshall et al. reference in Section VIII*).

All scans were obtained using a standardized protocol. Calibration standards with known hydroxyapatite concentrations (150, 75 and 0 mg/cm³) (Image Analysis Inc.) were included with the participant in each scan. Lumbar scans were obtained from 5mm above the L1 superior endplate to 5mm below the L2 inferior endplate at settings of 120 kVp, 150 mA, 1-mm slice thickness and 512x512 matrix in spiral reconstruction mode. Abdominal scans were obtained from the mid-L3 vertebra through the mid-L5 vertebra at settings of 80 kVp, 140 mA, 5-mm thickness and 512x512 matrix in spiral reconstruction mode. Hip scans were obtained in the pelvic region from the femoral head to 3.5 cm below the lesser trochanter at settings of 80 kVp, 280 mA, 3-mm slice thickness, and 512 x 512 matrix in spiral reconstruction mode. Men with a history of hip replacement were ineligible for hip scans. (*Additional details regarding the scanning protocol are available on the MrOS Study website in Study Documents, Baseline Operations Manual, QCT*).

Scanner models used at the sites were GE Prospeed (Birmingham), GE Hispeed Advantage (Minneapolis), Phillips MX-8000 (Palo Alto), Seimans Somatom +4 (Pittsburgh), Phillips CT-Twin (April-July, 2000, 190 participants) and Toshiba Aquilion (December 2000-March 2002, 467 participants) (Portland), and Picker PQ-5000 (San Diego). All scans were transferred to UCSF for central quality review and image processing.

II. MrOS Visit1 QCT Image Processing Procedures

Image processing occurred centrally at UCSF using software specifically developed for this purpose. Image processing was performed under the direction of Thomas Lang, PhD, using published methods (*see Lang et al. references in section VIII*). Images were calibrated from the native scanner Hounsfield Units (HU) to equivalent concentration (g/cm³) of calcium hydroxyapatite contained in

the calibration standard, which was contained in the field of view in all scans. This step reduces variability in image attenuation across scanners, since all HU are scaled to materials of known density.

The scanner at the Birmingham site used a different voxel size than scanners at the other MrOS sites. This difference affected the volume and BMC measures in the hip, owing to the reformatting that was necessary to produce these measures. The variables affected were those from the total femur, trochanter, and femoral neck regions of interest. To account for this, voxel size corrections were made to the relevant measures. This correction is noted in labels for the QCT variables: they contain the phrase (**vox corr**) or (**vox co.**).

Once processing was underway, it was noted that there was substantial variation in the hip measures in particular between scans obtained at different MrOS study sites. This variability is likely due to the different scanners used. Thus, in 2004, a study group formed and met at UCSF to review the image processing procedures. Several potential correction approaches were developed, and Tom Lang reprocessed a number of scans to evaluate the utility of applying these adjustment factors. These factors were derived from scans of a commercial torso phantom (Image Analysis, Inc.), which were obtained on all machines used in our study. However, as these adjustments did little to further reduce between-scanner variability in the measures, they were not incorporated into the image processing protocol.

Because of the variability introduced by the use of different scanners, **it is recommended that all analyses using QCT data include adjustment for clinic site.** The reason to adjust for SITE is that between-site variation contributes substantially to the total variance of the CT variables. This stands in contrast to the DXA BMD variables for which between-site variation is very low, perhaps because the same scanners were used at all sites. Thus, at least some of the between-site variation in the CT variables may be due to machine differences. Therefore, adjustments for SITE should be made either with indicator terms for each clinic site or by specifying SITE as a ‘class’ variable.

III. Regions of interest

Regions of interest (ROI) in the left proximal femur were identified in the QCT images. These regions include the total hip, trochanter, femoral neck, and femoral shaft. In the lumbar spine, there are many regions of interest. Measures in each lumbar region are made separately for the L1 and L2 vertebrae. *Details and illustrations are provided in file, QCT_INFORMATION_PART2.pdf.*

IV. Reasons for missing data

QCT scans were not acquired for all men who were referred for scanning, and not all scans could be successfully processed. Furthermore, men with hip replacement were not eligible to undergo the hip scans (they could still undergo the lumbar and abdominal scans). Missing value codes are included in the data files so that analysts can determine the reasons for missing data. The tables below show the variables that record whether a participant had a scan of a particular type and the reason that hip or spine data are missing (eligibility, acquisition, processing), whether there are missing data, and the codes for the reason that data are missing. The MrOS special missing value codes (SMVC) .A, .M, .N, and .R are used (*see SMVC.pdf in general MrOS documentation*). The variable names are

shown as the column headings, and the last column shows the numbers of men coded with a particular combination of the variables.

The values for QHQCHIP, QHMISHP, QSQCL1L2, QSMISSP are 0=no or 1=yes. The values for the remaining variables the special missing value codes .A (missing, representing an 'acquisition' error), .M (not applicable), .N (cannot evaluate, representing a 'processing' error) or the following numeric codes:

0='0 Scan not sent to UCSF or improperly archived'
 1='1 Data was lost due to archive failure at UCSF'
 2='2 Corrupt media transfer'
 3='3 Hip replacement (not eligible for scan)'
 4='4 Metal implant interfered w/acquisition or processing'
 5='5 Insufficient number of images for processing'
 6='6 Incorrect participant position'
 7='7 Incorrect phantom position or phantom missing'
 8='8 Existing disease interfered w/acquisition or processing'
 9='9 Scan failed processing--Unknown Reason'

Table 1. Status of hip scans (QH1OCT10)

Status of hip scans among 3786 men referred for QCT:	QHQCHIP (Had hip scan?)	QHMISHP (Missing hip data)	QHMISHPC (Missing hip data type)	QHMISHPR (Reason missing hip data)	Number
Ineligible for hip scan (hip replacement)	0, 1	1	.A	3	122
Refused	0	1	.R	.R	1
Failed hip scan acquisition	0, 1	1	.A	.A, 0, 1, 2	103
Scan acquired	1	0, 1	.M, .N	NOT (0,1,2, 3,.R)	3560
Scan failed processing	1	1	.N	4, 5, 6, 7, 8, 9	133
Scan processed	1	0	.M	.M	3427

Table 2. Status of lumbar (L1L2) scans (QS1OCT10)

Status of L1L2 scans among 3786 men referred for QCT:	QSQCL1L2 (Had L1/L2 scan?)	QSMISSP (Missing spine Data)	QSMISSPC (Missing Spine Data Type)	QSMISSPR (Reason missing spine data)	Number
Refused	0	1	.R	.R	0
Failed L1L2 scan acquisition	0, 1	1	.A	.A, 0, 1, 2	102
Scan acquired	1	0, 1, 2, 3	.M, .N	NOT (0,1,2, 3,.R)	3683
Scan failed processing	1	1	.N	4, 5, 7, 8, 9	126
Scan processed	1	0, 2, 3	.M	.M	3557

V. Hip measures

File QH1OCT10 contains the measures derived from the hip scans.

A. Hip regions of interest

The region of interest is indicated by the 3rd and 4th letters in the variable name, as follows:

TH=total hip region of interest

TR=trochanter region of interest

FN=femoral neck region of interest

FS=femoral shaft region of interest

B. Clarification for some of the hip CT variable values

1. Negative BMD and BMC values

Negative BMD and BMC values are correct. *These values should not be deleted during analysis.* The negative BMD and BMC values are observed primarily in the trabecular region of interest.

The reason that negative BMD and BMC values are observed has to do with the way CT scanners record tissue density. CT density numbers—known as Hounsfield Units (HU)—are scaled to materials of known density, with the density of water set to 0. Tissues (or materials) that are less dense than water (e.g., adipose tissue) have negative HU. Tissues (or materials) that are more dense than water (e.g., muscle or bone) have positive HU.

The negative BMD and BMC values result because the voxels in the volume of interest are representing primarily fatty marrow tissues that have negative HU. This occurs when bone loss at the endosteal surface is extensive. Thus, participants with negative BMD or BMC values appear to have sustained considerable bone loss.

2. Calculated variables

A few variables were calculated and included in the hip QCT data file. These are measures of medullary volume (QH__MVOL) and the percentage of the integral volume that is cortical volume (QH__PCIV). These variables are noted with the phrase (**calc**), in the variable label. As explained above and in accord with Tom Lang's instructions, medullary volume was calculated by subtracting cortical volume from integral volume. The percent cortical volume variables provide an estimate of cortical thickness, which is difficult to measure accurately particularly in the femoral neck.

3. Medullary volume vs trabecular volume

When the size of the medullary compartment in the total hip, trochanter or femoral neck is of interest, the medullary volume variables (QHTHMOVOL, QHTRMOVOL, QHFNMVOL) should be used. The **trabecular volumes** measures (QHTHTVOL, QHTRTVOL, QHFNTVOL) **should not be used**, as they do not represent the endosteal boundary (*see QCT_INFORMATION_PART2.pdf*). The trabecular volume is a very small region defined by an erosion process and is created specifically for the measurement of trabecular BMD. The value for trabecular volume is useful only

in that it indicates the size of the volume resulting from the erosion. From the standpoint of skeletal biomechanics, the size of the medullary cavity is the dimension of interest, as this represents the loss of bone from the endosteal surface.

4. Minimal (QHFNCOSA), but not maximal (QHTRCOSA) cross-sectional area is missing

There are 76 observations where the total femur volume (QHTHIVOL), the maximal cross-sectional area (QHTRCOSA), and the axislength (QHFNAXIS) are observed, but the minimal cross-sectional area (QHFNCOSA) is missing. This pattern occurs because of the location of the region containing the minimal cross-sectional area. The slice where the minimal cross-sectional area occurs is near the acetabulum and there can be ‘leakage’ of the bone edges into the acetabulum, making the CSA value larger than it really is. It is expected that this edge detection problem will have minimal effect on the femoral neck BMD and volume variables. However, **it is recommended** that analyses **which include the measures of femoral volumes, axis length or maximal cross-sectional area**, be run with and without these observations **to determine whether there is an effect of this potential artifact on the results**.

5. Special notes about femoral shaft variables

a. *Missing values.* Users of the hip QCT data should be aware that there is a substantial proportion with missing shaft data. After excluding participants with missing hip data (QHMISHP), there are 355 additional observations for which shaft data are missing. These data are missing primarily because the scan was acquired incorrectly and the image did not contain the shaft region of interest.

b. *Shaft measures of dimension.* Image processing in the shaft resulted in variables that measure similar properties. These are: 1) shaft width and shaft cross-sectional area, and 2) shaft cortical area and shaft cortical thickness. The pairs of measures are highly correlated. The user should choose carefully which measures best represent the dimension of interest. Shaft medullary area is calculated by subtracting the shaft cortical area from the shaft cross-sectional area. Because of the way image processing occurred, it is not possible to similarly calculate an endosteal width from shaft width and shaft cortical thickness.

c. *Manual processing.* Many of the shaft images from the San Diego site were processed manually. A flag variable, QHFSUPDF, indicates the records for which manual processing occurred, so the user can investigate if there are differences resulting from the different processing approaches.

6. Biomechanical variables

Biomechanical variables such as cross-sectional moment of inertia and section modulus for the hip regions of interest are not included in the data files. It is possible that with further development these variables may be available in future data releases.

7. Complete sets of data in the hip regions

Not all hip measures were obtained on every hip QCT scan processed. To easily identify participants who have complete sets of measures in the hip regions of interest, flag variables were

added to the datafile. The table below shows the name of the flag variable and the QCT variables used in the creation of the flag. The flag variable is coded as 1 if there is a non-missing value in the QCT variable

Table 3. Total hip, trochanter and femoral neck flag variables

QCT Measure	Flag Variable name		
	QHTHDATA	QHTRDATA	QHFNDATA
Cross-sectional area		QHTRCSA	QHFNCSA
Integral volume	QHTHIVOL	QHTRIVOL	QHFNIVOL
Cortical volume	QHTHCVOL	QHTRCVOL	QHFNCVOL
Medullary volume	QHTHMOVOL	QHTRMOVOL	QHFNMVOL
Integral BMD	QHTHIBMD	QHTRIBMD	QHFNIBMD
Cortical BMD	QHTHCBMD	QHTRCBMD	QHFNCBMD
Trabecular BMD	QHTHTBMD	QHTRTBMD	QHFNTBMD
Integral BMC	QHTHIBMC	QHTRIBMC	QHFNIBMC
Cortical BMC	QHTHCBMC	QHTRCBMC	QHFNCBMC
Trabecular BMC	QHTHTBMC	QHTRTBMC	QHFNTBMC

Table 4. Shaft flag variable

QCT Measure	Flag variable name
	QHFSDATA
Diameter	QHFSDIAM
Cross-sectional area	QHFSCSA
Cortical area	QHFSCAR
Medullary area	QHFSMAR
Shaft BMD	QHFSBMD
Shaft BMC	QHFSBMC

VI. Lumbar spine measures

File QS1OCT10 contains the measures for the L1 and L2 vertebrae.

A. There are many different regions of interest as indicated by the 3rd and 4th letters in the variable name, including:

- VC=vertebral centrum
- VT=total vertebra
- VM=vertebral mid-centrum
- CB=central vertebral body
- MB=central mid-vertebral body
- SB=center slice vertebral body
- CL=spinal canal

Locations for most of these regions are illustrated in file, *QCT_INFORMATION_PART2.pdf*. Differences in the locations are somewhat subtle, so the user should think carefully about the choice of the ‘families’ of the variables to use.

B. Cortical measures from the lumbar scans should not be used

Variables pertaining to lumbar cortical measures **should not be used** in analyses. The reason is that the cortical shell in the vertebra is very thin and difficult to measure accurately. These variables that should not be used are: QSVTCBL1, QSVTCBL2, QSVTCBMD, QSVTCVL1, QSVTCVL2.

C. Complete sets of data in the lumbar regions

Because of the large number of vertebral measures, it is important for MrOS analyses to be consistent. The choice of which variables to use was guided by Tom Lang. Use of the measures associated with these flag variables will insure consistency among analyses. The user does not have to use these particular variables, but the analysis plan should state the reason that a different set of measures will be analyzed.

To easily identify participants who have complete sets of the recommended measures, flag variables are included in the datafile. These variables are called: QSL1DATA, QSL2DATA, and QSL12DATA. These flag variables were made for the presence of

- width (anterior-posterior and lateral) and cross-sectional area measures from the VC region
 - QSVCAWL1, QSVCAWL2
 - QSVCLWL1, QSVCLWL2
 - QSVCARL1, QSVCARL2
- integral and trabecular BMD and volumes from the VT (3-D) region
 - QSVTIBL1, QSVTIBL2, QSVTIBMD
 - QSVTTBL1, QSVTTBL2, QSVTTBMD
 - QSVTIVL1, QSVTIVL2, QSVTTVL1, QSVTTVL2
- integral and trabecular BMD and volumes from the VM (2-D) region
 - QSVMIBL1, QSVMIBL2, QSVMIBMD
 - QSVMTBL1, QSVMTBL2, QSVMTBMD
 - QSVMIVL1, QSVMIVL2, QSVMTVL1, QSVMTVL2

VII. Related documents

1. QC1AUG07_Information.pdf

2. QCT_Information_part2.pdf

Note that the variable names listed in this document are the ‘nicknames’ that Tom Lang used.

To map the nickname to the actual variable name in the dataset, use the rename documents listed below.

3. QH1AUG06_Renames.pdf

4. QS1AUG06_Renames_details.pdf

VIII. References

A. MrOS QCT Data:

1. Marshall LM, Lang TF, Lambert LC, Zmuda JM, Ensrud KE, Orwoll ES. Dimensions and volumetric BMD of the proximal femur and their relation to age among older U.S. men. *J Bone Miner Res* 2006; 21:1197-1206.

B. Methods used to derive the MrOS QCT measures:

1. Lang TF, Keyak JH, Heitz MW, Augat P, Lu Y, Mathur A, Genant HK. Volumetric quantitative computed tomography of the proximal femur: precision and relation to bone strength. *Bone* 1997; 21:101-118.

2. Lang TF, Li J, Harris ST, Genant HK. Assessment of vertebral bone mineral density using volumetric quantitative CT. *J Computer Assist Tomogr* 1999; 23:130-137.

3. Lang T, LeBlanc A, Evans H, Lu Y, Genant H, Yu A. Cortical and trabecular bone mineral loss from the spine and hip in long-duration spaceflight. *J Bone Miner Res* 2004; 19:1006-1012.

The MrOS Study

Guide to Hip and Spine Variables

QCT Reading Center

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Updated August 5, 2004

*minor adjustments made 3/27/15 by kpeters, where noted

Preface

This document is meant as a companion to the *MrOSQCT data dictionary*, which is essentially a list of QCT variables, along with brief descriptions and illustrations. The limitation of the dictionary is that the information is not organized in such a way as to allow an investigator unfamiliar with QCT to easily choose variables which would be useful for testing specific hypotheses or evaluating specific research questions. This document to classify the variables by the type of measurement (eg bone density, bone size, or bone strength estimate), and provides brief descriptions of how the measurements are made and their limitations.

This document is broken into three different sections:

1. Bone Density
2. Bone Size/Geometry
3. Bone Strength Estimates

Prior to the calculation of these variables, there are a set of manually driven operations in which an operator marks some image landmarks, such as the calibration phantom and certain anatomic locations in the vertebrae and hip, and draws some anatomic axes such as the femoral neck axis. During this process, the operator completes the following steps:

- Read in the scan.
- Calibrate the native image units to equivalent units of bone mineral concentration (g/cc hydroxyapatite).
- Manual definition of anatomic axes
- Crop the CT image around the bones being analyzed (L1, L2 or left hip)
- Resample the cropped image so that the bone is oriented along biomechanically relevant axes. For hip scans, the new slicing direction is along the femoral neck. For vertebral bodies the new slicing direction is perpendicular to the endplates.
- Determine the bone edges. This is just like DXA but is done in 3D.
- Thus for L1, L2 and the hip, we have two 3D images: (i) a cropped, calibrated, resliced data image in units of g/cm³ and (ii) a matched edge file in which the tissue within the periosteal boundary is set to a value of 1 and outside to 0. Slide 1 shows examples of edge images for hip and spine.

- Vertebrae that are severely compressed are not analyzed and data is set to .F(fracture) for these levels.

Bone Density measured by QCT in MrOS:

The analysis programs for the hip and spine process the data and edge images to determine volumetric regions of interest at specific anatomic sites. All BMD values are given in g/cm³. They reflect the tissue density of the analyzed volume calibrated to units of equivalent concentration of hydroxyapatite in g/cm³.

Bone density in the hip: For the hip, the anatomic regions are the femoral neck, the trochanter and the total femur regions.

Integral BMD is measured by calculating the average concentration in g/cm³ of all the voxels contained within the *periosteal* edge. The Integral BMD variables for the hip are tabulated in the MrOSData Dictionary as **NIBMD, TRIBMD and TOFIBMD** for femoral neck, trochanter and total femur respectively.

Trabecular BMD: The regions of evaluation for trabecular BMD are matched to the integral regions shown in Slide 2. The trabecular BMD variable names are **NTBMD, TRTBMD and TOFTBMD** for the femoral neck, trochanter and total femur regions respectively. The trabecular regions are created by applying an erosion operation to the boundaries of the integral regions. A fixed number of erosions is carried out, resulting in a trabecular region whose boundaries are well inside the cortex. The trabecular BMD is the average concentration in g/cm³ of all the voxels contained within the boundary of the trabecular region. It is important to note that this boundary **is not the same** as the endosteal boundary. Another point to note is that the marrow in the hip has a high fat content. This results in very low trabecular BMD values, particularly in the femoral neck, where the low concentration of bone and the high concentration of marrow fat, results in BMD values near or less than zero. Despite marrow fat errors, the QCT trabecular BMD is highly correlated to the mineral mass, elastic modulus and strength of the trabecular bone matrix. This has been established from biomechanical studies in which cylindrical cores of trabecular bone have been removed from sites (femur, tibia, vertebrae) rich in fatty marrow. The CT BMD measured from these sites generally correlate very well with measures of ash density, elastic modulus and strength.

Cortical BMD: The cortical BMD variable names are: **NCBMD, TRCMBD and TOFCBMD** for the femoral neck, trochanter and total femur regions respectively. The cortical regions are derived by applying a threshold of 0.35g/cm³ to those voxels within the periosteal boundary but outside the boundary of the trabecular region. The cortical BMD is thus the mean concentration of those voxels between the trabecular and periosteal boundaries whose concentrations are above 0.35 g/cm³. The concentrations measured at the femoral neck are lower than the true value for pure cortical bone. This is because the thickness of the proximal femoral

cortices is smaller than the resolution of the CT image in some regions of the cortex in the hip. The cortical density measured in MrOSCT scan ranges from 0.4-0.6 g/cm³, and primarily reflects the thickness of the cortex and also the porosity of the cortical material.

BMD Femoral shaft: SHABMD is the BMD in g/cm³ of the cortical bone in the femoral shaft. The femoral shaft measurement is described in greater detail in the section on bone size.

Bone Density in the L1 and L2 vertebrae: For the vertebrae, there are integral, trabecular and cortical regions of evaluation. There are two classes of regions: 3D regions are calculated using the whole vertebral body and 2D regions are calculated from the 10-mm slice in the mid-vertebra section. All BMD values are measured as hydroxyapatite equivalent densities in g/cm³. The program calculates several 3D and 2D regions which provide essentially identical information. The following regions are recommended:

Integral BMD: The integral bone density is the average of all of the values within the periosteal boundary.

DIBMD3 contains the entire vertebra, excluding the transverse processes. It essentially matches to the region of bone quantified by AP DXA.

DCLBMD3 contains the vertebral centrum only, excluding all of the posterior elements. It essentially matches to the region of bone quantified by lateral DXA.

MCBMD is calculated from the mid-section of the centrum.

Trabecular BMD: We recommend using **DTBMD2** as a measure of vertebral trabecular bone density. It is calculated from the a region encompassing most of the trabecular bone in the mid centrum. The trabecular BMD is defined as the mean concentration in g/cm³ of all of the voxels within this region. As with the trabecular region in the hip, the DTBMD3 is affected by marrow fat errors. But as with the hip, the BMD of cores of trabecular bone extracted from cadaveric vertebrae (from elderly donors) are highly correlated with mechanical measurements such as elastic modulus and strength. DTBMD3 variables are the average of the L1/L2 values. If either the L1 or L2 values are set to a missing value, then the average is just the valid value of the other level.

Bone Size measured by QCT in MrOS:

Bone size parameters in hip: In the hip, we calculate cross-sectional areas, volumes and a proximal femoral axis length.

MINCSA: This is the minimum cross sectional area of the femoral neck. The hip

analysis program searches along the femoral neck axis, and computes the periosteal area at each position.

MAXCSA: This is the maximum cross sectional area found by the program. It is found in the trochanteric region.

NIVOL: The periosteal volume of the femoral neck region.

NCVOL: The volume of cortical bone in the femoral neck region. The true **trabecular volume** is actually **NIVOL-NCVOL**.

TRTVOL: The periosteal volume of the trochanteric region.

TRCVOL: The cortical volume of the trochanteric region.

TOFIVOL: The periosteal volume of the total femur region.

TOFCVOL: The cortical volume of the total femur region.

AXISLENG: the distance in mm between the position of MINCSA and the position of MAXCSA. It is a measure of the femoral component of hip axis length.

Bone size parameters in femoral shaft: The during the analysis process, the operator marks the lesser trochanter. This analysis program reconstructs a femoral shaft plane 3 cm inferior to the lesser trochanter. This reconstructed image contains information on bone size and geometry in a primarily cortical site in the skeleton. The parameters measured at the shaft include cross-sectional areas and cortical thickness.

SHACSA: The periosteal area of the femoral shaft

SHACORHI: The thickness of the femoral shaft cortex. This is the mean thickness of the shaft measured by rotating a line profile through the center of the shaft, and measuring the thickness of the cortex along each profile.

CAAREA: the area of the femoral shaft cortex.

Bone size parameters in the L1 and L2 vertebrae: The primary size variables are the cross-sectional area and dimensions of the mid vertebral centrum and the vertebral body volume.

VBCSAL1 and VBCSAL2: these are the periosteal areas of the mid-vertebral centrum in the L1 and L2 vertebral bodies.

APVWL1 and APVWL2: these are the widths of the vertebral centrum measured along the AP mid- line of the centrum from the anterior aspect of the spinal canal to the anterior aspect of the vertebral cortex.

LAVWL1 and LAVWL2: these are the widths of the vertebral centrum measured along a horizontal line at the anterior aspect of the spinal canal.

DCLV3L1 and DCLV3L2: these are the vertebral centrum volumes. The periosteal volumes of tissue in the lateral- like region.

Bone Strength estimated by QCT in MrOS

*The following paragraph updated by kpeters 03/27/15

Bone Strength variables for section modulus and bending strength were included in previous releases of MrOS data but are no longer included due to assumptions used in creation of the variables that were deemed to not be rigorous enough. However, we do have other QCT data on bone strength in MrOS, namely the finite element analysis datasets FE1 and FS1 for hip and spine, respectively. Please see documentation files for additional information about these datasets.

Summary of recommended variables:

Volumetric QCT bone density variables: hip

Integral

NIBMD FEMORAL NECK, INTEGRAL BONE, BMD (G/CC)

TRIBMD TROCHANTER, INTEGRAL BONE, BMD (G/CC)

TOFIBMD TOTAL FEMUR, INTEGRAL BONE, BMD (G/CC)

Trabecular

NTBMD FEMORAL NECK, TRABECULAR BONE, BMD (G/CC)

TRTBMD TROCHANTER, TRABECULAR BONE, BMD (G/CC)

TOFTBMD TOTAL FEMUR, TRABECULAR BONE, BMD (G/C)

Cortical

NCBMD FEMORAL NECK, CORTICAL BONE, BMD (G/CC)

TRCBMD TROCHANTER, CORTICAL BONE, BMD (G/CC)

TOFCBMD TOTAL FEMUR, CORTICAL BONE, BMD (G/CC)

Volumetric QCT bone density variables: spine

Integral

DIBMD2 SINGLE SLICE INTEG. BONE, AVG L1L2 BMD

DIBMD3 AP DXA-LIKE VERT., AVG L1L2 BMD (G/CC)

DCLBMD3 LAT.DXA-LIKE VERT., AVG L1L2 BMD (G/CC)

MCBMD X-SECTION MID-VERT BODY, AVG L1L2 BMD (G/CC)

Trabecular

DTBMD2 SINGLE SLICE TRABEC. BONE, AVG L1L2 BMD (G/CC)
DTBMD3 TOT. VERT. TRABEC. BONE, AVG L1L2 BMD

Bone size variables: Hip

MAXCSA MAX X-SECTION AREA OF INTER-TROCH. (CM₂)
MINCSA MIN X-SECTION AREA OF FEM. NECK (CM₂)
AXISLENG DIST. MIN/MAX X-SECTION F.NECK AXIS(CM)
NIVOL FEMORAL NECK, INTEGRAL BONE, VOL (CC)
NCVOL FEMORAL NECK, CORTICAL BONE, VOL (CC)
TRTVOL TROCHANTER, TRABEC. BONE,VOL (CC)
TRCVOL TROCHANTER, CORTICAL BONE, VOL (CC)
TOFIVOL TOTAL FEMUR, INTEGRAL BONE, VOL (CC)
TOFCVOL TOTAL FEMUR, CORTICAL BONE, VOL (CC)

Bone size variables: Shaft

SHACSA SHAFT, CROSS-SECTIONAL AREA (CM₂)
SHACORHI SHAFT, X-SECTION,CORT.BONE THICK.(CM₂)
CAREA SHAFT, CORTICAL BONE AREA (CM₂)

Bone size variables: Spine

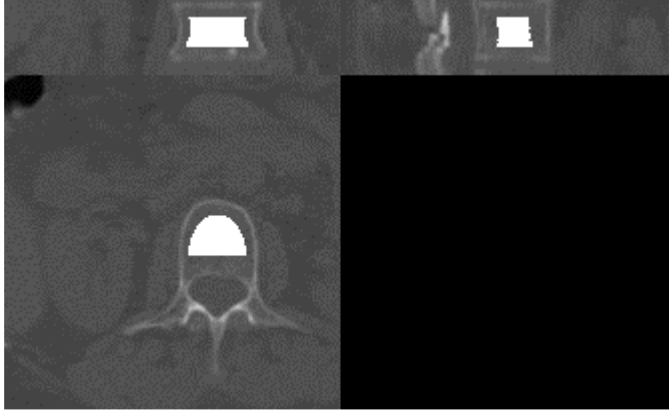
APVWL1 VERT. BODY, AP AXIS, L1, WIDTH (CM)

Variable Illustration

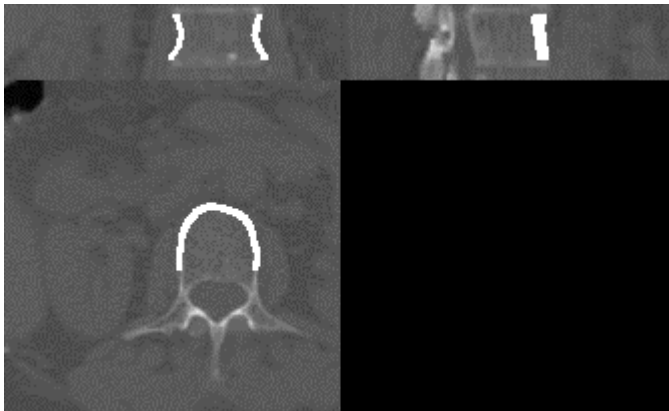
Vertebral regions of interest: These consist of 3D regions of interest encompassing the entire vertebral volume or large fractions thereof, as well as 2D regions defined on the mid 10- mm of the vertebra (for comparability to earlier QCT technique)

3D regions

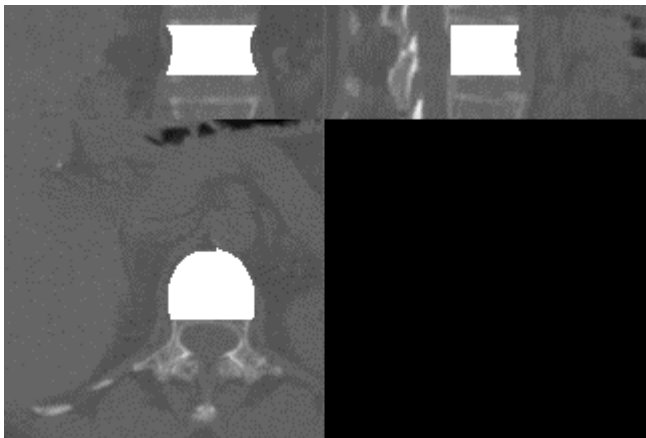
3D trabecular BMD : trabecular BMD defined in the central 70% of the vertebral body



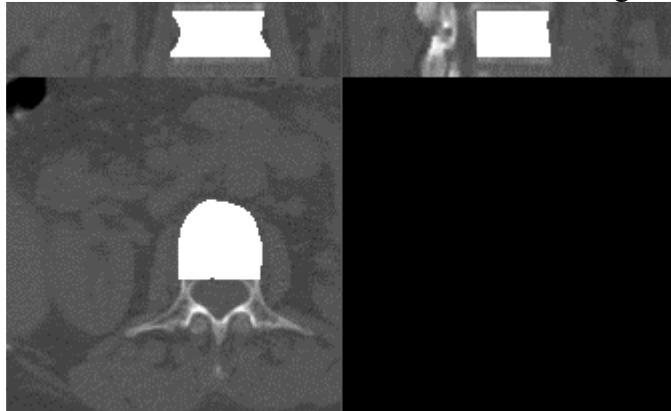
3D cortical BMD: matched to 3D trabecular BMD



3D centrum BMD: similar to lateral DXA

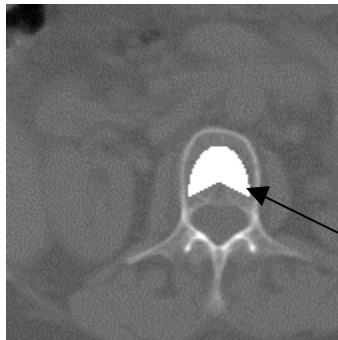


3D interior centrum BMD: similar to interior region of lateral DXA



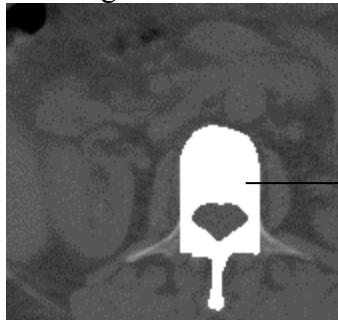
2D regions: the central 10-mm of the vertebral body is reconstructed from the volumetric scan. Trabecular and integral regions of interest are delineated on the reconstructed midslices to provide comparability with earlier single-slice QCT approaches.

2D trabecular BMD



DTBMD2 - Single Slice
Trabec. Bone, BMD

2D integral BMD

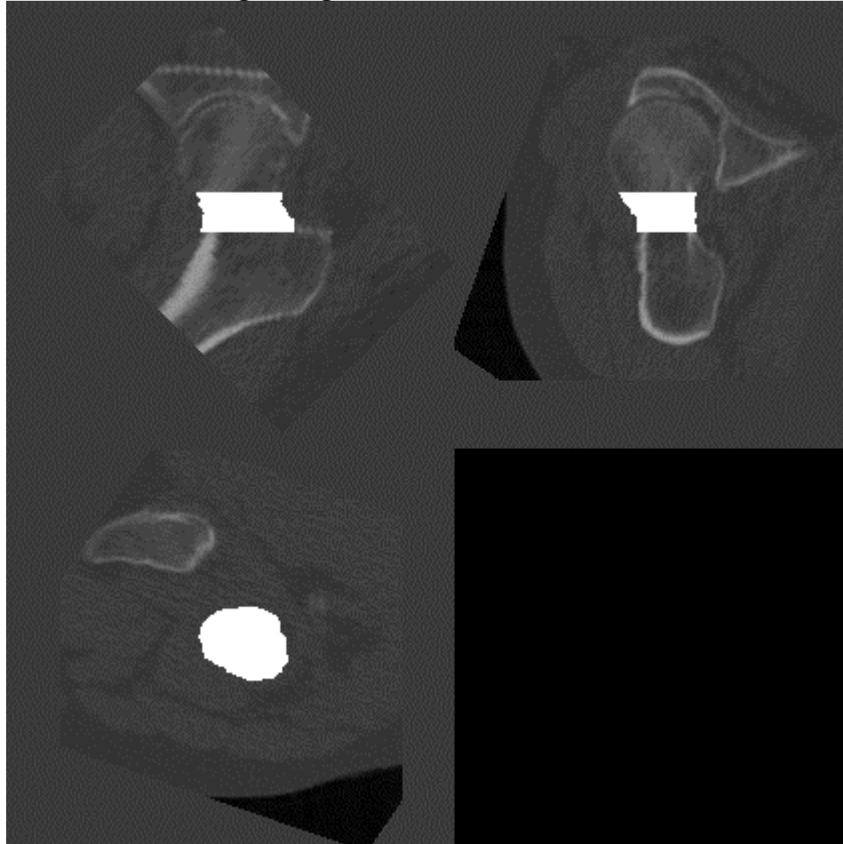


DIBMD2 - Single Slice
Integ. Bone, BMD

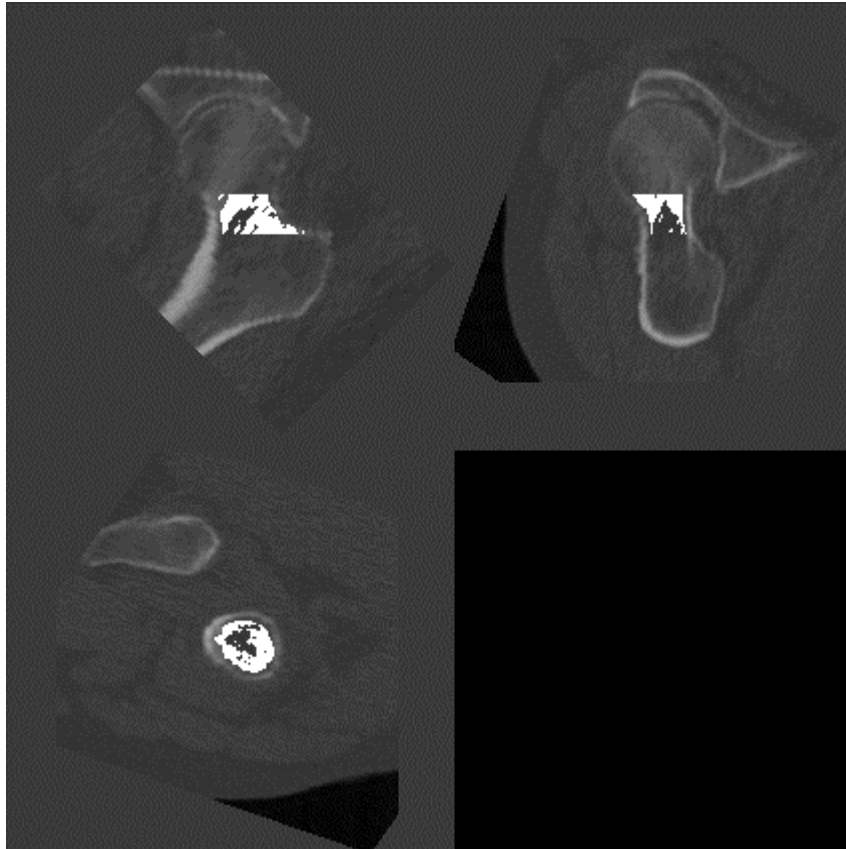
Proximal Femoral Regions of Interest: The hip regions consist of cortical, trabecular and integral regions in the femoral neck and trochanteric regions, as well as a total region

combining these two. In the trabecular regions of interest, a threshold of 0 g/cc applied to remove regions containing fat from the BMD calculation, and an upper threshold of 0.35 g/cc is applied to remove cortical components such as the calcar from the BMD calculation. Images are displayed as a set of sagittal, coronal and axial views.

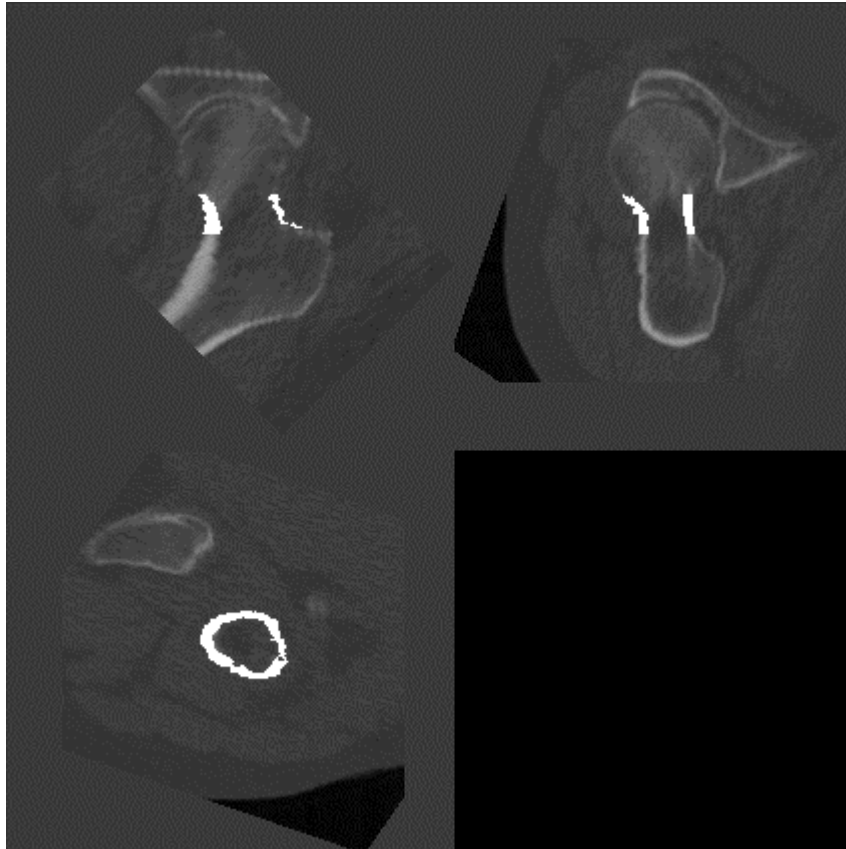
Femoral neck integral region of interest:



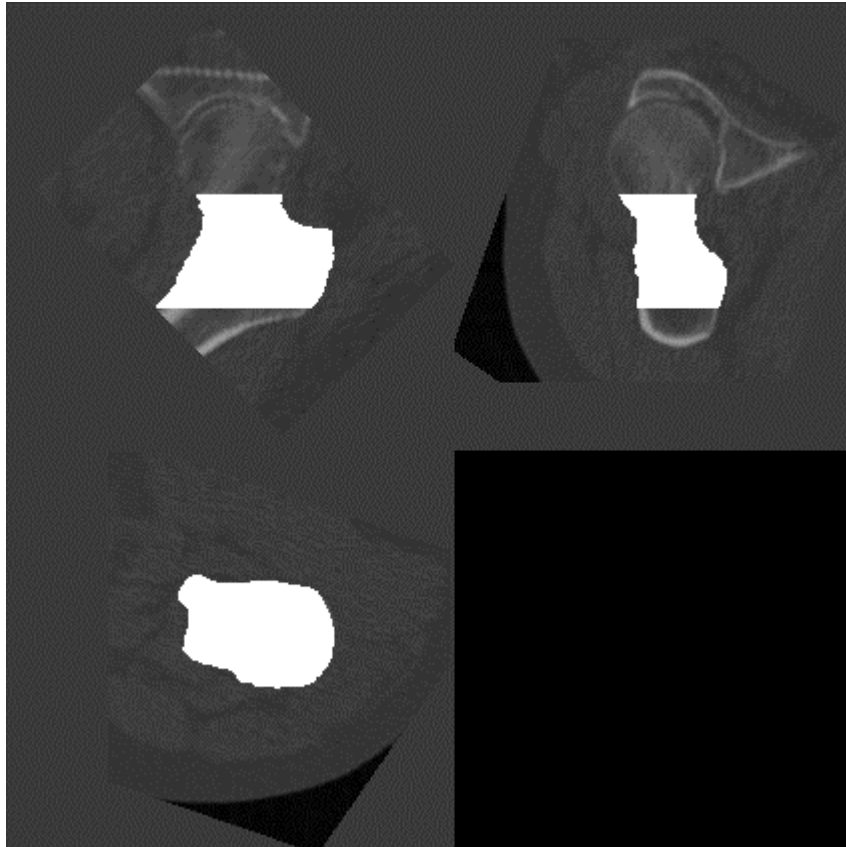
Femoral neck trabecular region of interest



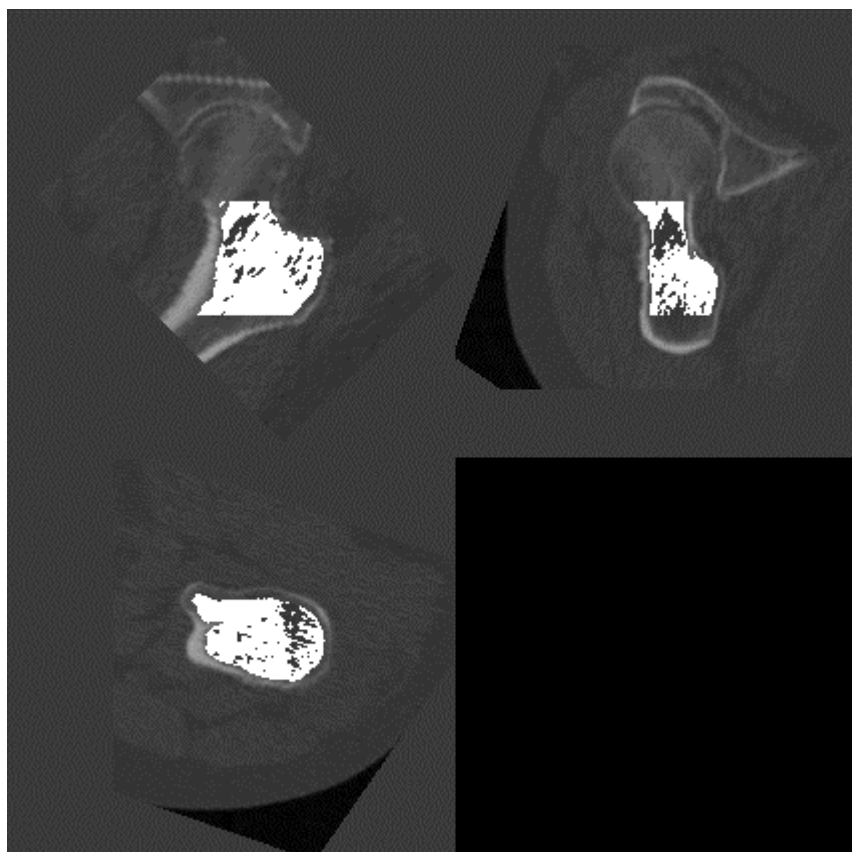
Femoral neck cortical region of interest



Total femur integral



Total femur trabecular



Total femur cortical

