Effect of Body Size on the Quantification of Bone Mineral Density from QCT Images Using a Novel Anthropomorphic Hip Phantom

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BACKGROUND

- Pharmaceutical and epidemiological studies often employ quantitative computed tomography (QCT) to estimate volumetric bone mineral density (BMD), bone geometry and strength [1-3].
- Variations in body size and shape, and in bone size and density, result in beam hardening errors that heterogeneously distort image intensities and BMD [4].
- Beam hardening effects may cause BMD measurement artifacts in people of different sizes, and contribute to degradation of data when scanners are changed.

AIM

- To investigate the effect of body size and bone density on BMD measurements using a novel anthropomorphic hip phantom for different scanners.

ANTHROPOMORPHIC HIP PHANTOM (AHP)

- The AHP was designed to study the effect of variable body size and pelvic anatomy on hip BMD measurements.
- It contains a calibration neck to correct the measured BMD and a test neck to evaluate BMD measurements.

EXPERIMENT

- The AHP was scanned in 6 different variations, combining different (old/young) body size and body shapes (no/small/large girdles).
- The scans were acquired on 2 GE VCT 64 systems, 1 Siemens Biograph and 1 Siemens Definition, at UCSF and MAYO Clinic.
- The AHP was scanned with the patient calibration phantom, which is commonly used to calibrate subject images in QCT.

MEASUREMENT OF BMD FROM IMAGES

- We calibrated each image with the calibration phantom.
- We calculated cortical, trabecular and integral BMD using calibration and test hips.
- We chose the Siemens Biograph as reference for its less dependence to body size.
- We computed regression equations of calibration hip BMD for each scanner against reference scanner.
- We applied calibration hip regression to each image and compared pre- and post correction measurements.

BMD OF TEST HIP BEFORE AND AFTER CORRECTION

- Larger BMD differences were found on the cortical bone of femoral neck and greater trochanter.

MEASUREMENT OF BMD IN CALIBRATION AND TEST HIPS

- Calibrations of acquired image to BMD units
- Regression equations against reference scanner
- Calibration of acquired image to BMD units
- Measurement of BMD in calibration and test hips

DISCUSSION

In this study we analyzed the consequences of variable body size on BMD measurements using the AHP. We found that:

- Values of cortical BMD decrease dramatically with increasing body size.
- Inter-scanner differences are body size dependent, especially for cortical BMD.
- Body size dependence was more visible for the GE VCT 64 systems and the Siemens Definition.
- Corrections based on calibration hip dramatically reduced inter-scanner errors implications.
- Artifactual reductions of BMD with increasing weight compensate measurements in obese patients and patients undergoing weight loss.
- Special consideration is required for bone strength estimates. Elastic modulus estimates vary with BMD, and cortical voxels are located farthest from neutral axis.
- Results show poorer efficacy for correcting thin structures such as cortical femoral neck. We are carrying out studies to address potential interaction between spatial resolution and inter-scanner/body weight variations.
- Overall, initial results show promise for phantom-based corrections to reduce variations in BMD between scanners and patients.

APPLICATION TO HUMAN SUBJECTS

- We are currently working on applying the inter-scanner corrections to human subjects, where the same subject was scanned on two different scanners.
- Analyses of body size and inter-scanner corrections on bone strength are currently underway.

REFERENCES


MORE INFORMATION

Information and technical details about this study are available at https://sites.google.com/site/serenanabonaretti/asbr2013

Acknowledgment

The project is funded by NIH/NIAMS S01AR060700

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