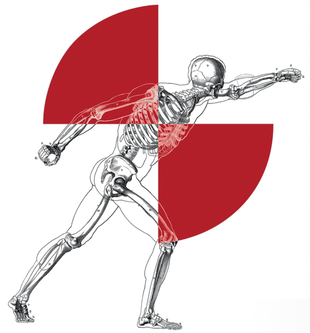

Methodology Dependent Variation in Volumetric Bone Mineral Density

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INTRODUCTION

- Fracture risk increases independently of dual energy x-ray absorptiometry (DXA) t-scores calculated from areal bone mineral density (aBMD).[1]
- Quantitative computed tomography (QCT) utilizes phantom calibration rods of known densities to quantify volumetric BMD (vBMD) which can provide a more thorough assessment of skeletal mineralization than DXA.[2]
- However, potential variation in attenuating x-ray photons within QCT scans may influence the Hounsfield Units (HU) of phantom rods and resulting calibration curves which can misrepresent vBMD and differential fracture risk.

The objective of this study is to assess variation in vBMD when using a location-specific phantom calibration compared to a general scan-specific phantom calibration.

MATERIALS and METHODS

- n=50 male post-mortem human subjects (PMHS) with ages ranging from 24 to 89 years (61 ± 14) were scanned on clinical quality CT systems (0.6mm slice thickness, 120 kVp, variable reference mAs) with an INTable^{TM} phantom containing rods of known densities (0mg/cc to 150mg/cc).
- A validated custom MATLAB code was used to obtain HU values from each phantom rod (Fig.1) at the anatomical locations of L2, L3, L4, the left femoral neck (L Fem-neck), and the left calcaneus (L Calc).
- For each scan, location specific calibration curves (LS) were created from phantom rods at each volume of interest (VOI). A general scan specific calibration (Gen.) curve was created from L3 anatomical location. (Figs. 2 and 3)
- Osirix MD was used to manually collect mean HU from a VOI of 3 skeletal tissue types: trabecular (Tb) cortical (Ct), and Total (Tb and Ct) (Table 1).
- vBMD was then calculated for each VOI using the regression equations for both Gen. and LS calibration curves (Fig. 4).

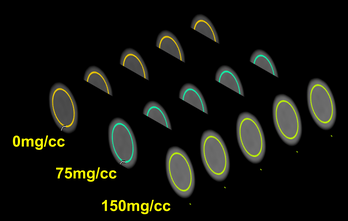

Figure 1: Phantom rod VOI's with known densities of 0mg/cc, 75mg/cc, and 150mg/cc

Anatomical locations	Tissue Type
L2	Total and Tb
L4	Total and Tb
L Fem-Neck	Total, Tb, Ct Inferior (Inf), and Ct Superior (Sup)
L Calc	Total and Tb

Table 1: Skeletal VOIs collected from each PMHS. 10 VOIs collected per PMHS for a total of 500 VOIs analyzed from this sample.

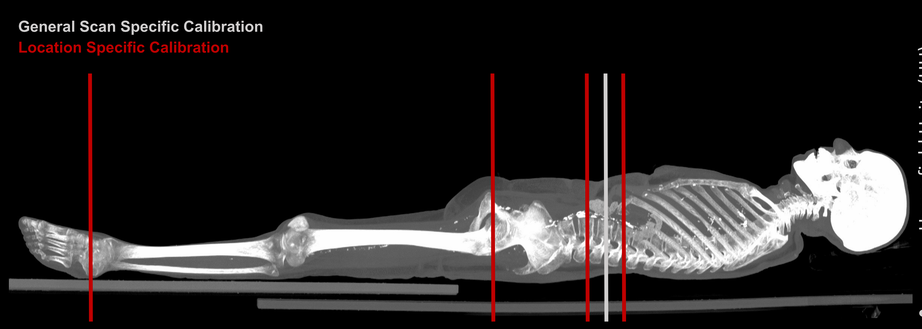

Figure 2: Sagittal view of a PMHS indicating anatomical sites for location specific calibration curves (red) and general scan specific calibration curves (grey) constructed from phantom rod HU values and their known densities.

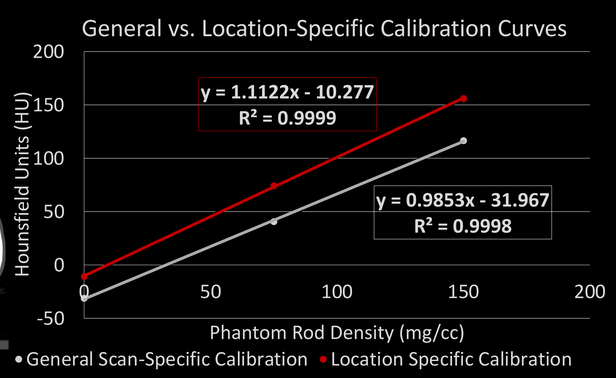

Figure 3: Example of a location specific and general scan specific calibration curve

RESULTS and DISCUSSION

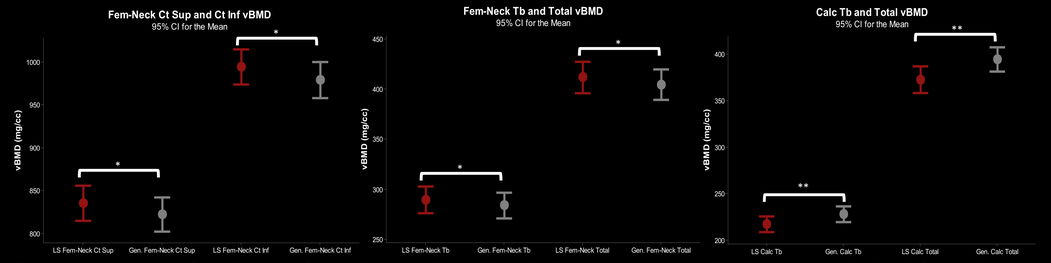

Figure 4: Interval plots of Calc, Fem-Neck Ct, and Fem-Neck Tb and Total vBMD values derived from LS calibration curves (red) and Gen. calibration curves (grey). *=p<0.01 **=p<0.001

Skeletal VOI	LS vBMD	Gen. vBMD	Percent Difference	p-value
L2 Tb	222.14	221.66	-0.217%	0.755
L2 Total	296.05	295.24	-0.271%	0.664
L4 Tb	235.42	236.91	0.632%	0.397
L4 Total	322.31	324.58	0.704%	0.301
L Fem-neck Tb	289.30	283.78	-1.908%	**0.002**
L Fem-neck Total	411.55	404.23	-1.778%	**0.002**
L Fem-neck Ct Sup	834.80	821.60	-1.589%	**0.004**
L Fem-neck Ct Inf	994.20	978.80	-1.553%	**0.005**
L Calc Tb	216.83	227.98	5.147%	**<0.001**
L Calc Total	372.35	394.16	5.858%	**<0.001**

Table 2: Paired t-test results of vBMD from LS calibration curves and Gen. Calibration curves. Significant differences were found in all Fem-neck and Calc sites (p<0.01) but not in any lumbar site (p>0.01)

- Paired t-tests compared each VOI's location specific (LS) vBMD and general scan specific (Gen.) vBMD (Fig 4 and Table 2).
- Results showed that variation in lumbar spine calibration curves do not have a significant influence on vBMD in the region. This lack of variation in vBMD values is likely due to the close proximity (and similar attenuation) of the LS and Gen. calibration curves.
- However, using a Gen. calibration curve demonstrated a significant overestimation of vBMD within the calcaneus (5.15% to 5.86%) but a significant underestimation within the femoral neck (-1.55% to -1.91%).
- These trends were exaggerated in the Tb VOIs for the Fem-neck with increased negative difference but decreased in the Calc which may be a result of differential linear x-ray attenuation across the PMHS.

CONCLUSIONS

- Utilizing a single scan-specific calibration curve to quantify vBMD may significantly alter assessments of differential fracture risk in other regions of the body.
- Variation in over/underestimation of vBMD when utilizing a general scan specific calibration curve may differentially impact fracture risk thresholds and material properties of finite element models.
- Additional research is needed to understand how non-location specific calibration curves may influence vBMD elsewhere within the body and investigate the influence of age, sex, and body size on these results.

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ACKNOWLEDGEMENTS

The authors would like to thank the anatomical donors for their generous gifts. Thank you to all the students, staff, and faculty of the Injury Biomechanics Research Center for all their support throughout this project.

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