# Accuracy of BMD measurement in weight bearing, cone-beam CT

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## Purpose

Knee osteoarthritis (KOA) is a common, painful, and disabling joint disorder. Changes in BMD at the knee are associated with worsening clinical and radiographic outcomes, such as pain and structural progression of KOA. Weight-bearing, cone-beam CT (WBCT) allows cross-sectional, functional imaging of the knee for assessment of bone and joint structures but is challenged by artefacts that may compromise the accuracy and precision of BMD measures. Therefore, we compared BMD measurement accuracy between WBCT and multi-slice CT (MSCT) using a BMD calibration phantom. In addition, we sought to determine the dependence of BMD measurement on the presence of a participant to determine whether synchronous BMD calibration is feasible.

## Methods

We scanned a BMD calibration phantom (QRM, Möhrendorf, Germany) including three hydroxyapatite cylindrical inserts of 100, 400 and 800 mgHA/cm$^3$ with WBCT (HiRise, CurveBeam) and MSCT (Revolution GSI, GE). Two image acquisitions were completed with each scanner: 1) a phantom image (asynchronous calibration) and 2) a phantom + participant image (synchronous calibration). Within each BMD insert, we selected four regions of interest to facilitate BMD calibration and uniformity analysis. We used one sample t-tests and relative error measurements to compare measured BMD to true BMD, whilst paired t-test, regression and Bland-Altman analysis were used to compare measured BMD between scanners and calibration techniques.

## Results

For all CT scans, measured BMD values were significantly different from the true BMD value ($p < 0.001$; Fig. 1). Relative errors from true BMD were larger for WBCT (-16% to 8%) than for MSCT (-1.3% to 3%). Although the mean BMD measurements for synchronous WBCT images were closer to the true BMD, the standard deviations were 2.0% - 10.3% higher (w.r.t. true BMD) compared to asynchronous images. In contrast, MSCT scans were unaffected by the presence of a participant. Whilst regression analysis showed a high association between WBCT and MSCT measures ($R^2>0.99$), Bland-Altman analysis suggested that WBCT and MSCT showed better agreement when BMD was measured asynchronously.

## Conclusion

Our results suggest that WBCT BMD measures are more variable than MSCT measures. Furthermore, WBCT measures are more accurate when measured with a participant in the scan and may need to be calibrated at the height where BMD will be measured. Together, our data support the use of synchronous calibration for BMD measurement using WBCT.

# Figure

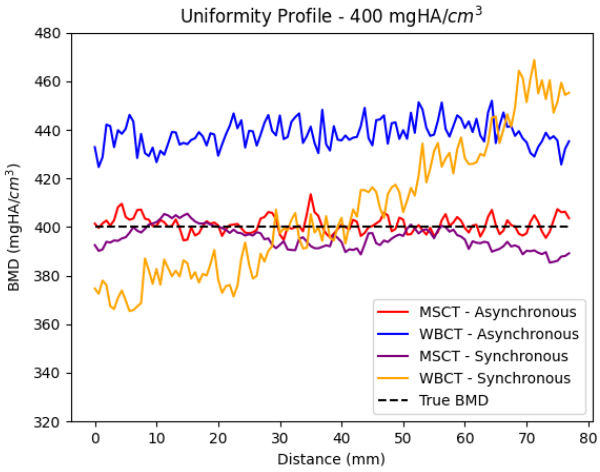


**Fig. 1.** Uniformity profiles for WBCT and MSCT taken along the longitudinal axis of the leg.