CurveBeam AI

ADVANCING ACCURACY IN ORTHOPEDIC IMAGING

WHITE PAPER

Validating Image Quality of HiRise Extremity CT Imaging for Orthopedic Applications Requiring Segmentation of CT Anatomical Data

Weight Bearing Cone Beam Computed Tomography (WB-CBCT) has emerged as a transformative tool in orthopedic imaging, particularly for foot and ankle surgical planning and musculoskeletal diagnostics. Unlike Multidetector CT (MDCT), CBCT employs a cone-shaped beam and a single 360° rotation to generate high-resolution, three-dimensional images. Generally, this approach not only reduces radiation exposure but also enables imaging in upright, weight-bearing positions.

By capturing joints under physiological load, WB-CBCT enables visualization of bone alignment, joint relationships, and impingement patterns that may differ from conventional supine imaging. These features position CBCT as a diagnostic adjunct that supports orthopedic assessment, surgical planning, and implant selection.

Image Quality Comparison: CBCT vs MDCT

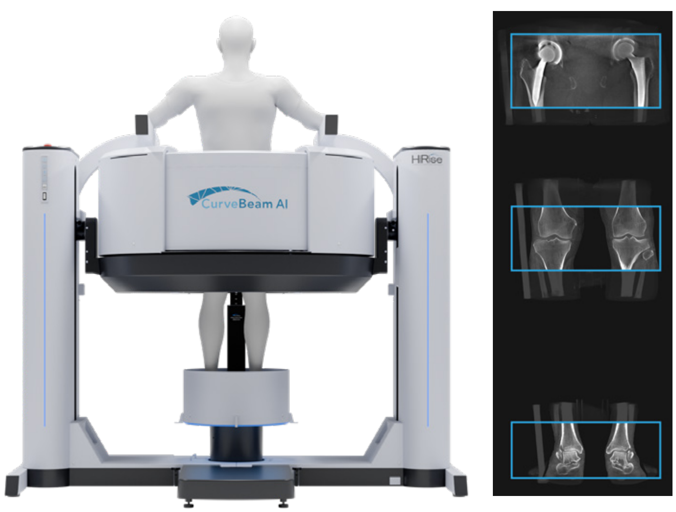
Prior technical analyses have demonstrated that modern CBCT achieves image quality comparable to MDCT through innovations such as fine voxel resolution, advanced scatter reduction, and optimized reconstruction algorithms. These upgrades deliver consistent, detailed visualization of bone structures in functionally relevant positions, ensuring confidence in preoperative planning.

CurveBeam AI conducted an internal investigation to determine whether segmentability of scans from its HiRise WB-CBCT was comparable to MDCT. A secondary aim was to determine if dose settings on the HiRise affected segmentability of the scans.

Study Design and Methods

Four lower-body specimens, from pelvis to foot, representing a range of body mass indices (BMIs) were scanned with MDCT using a standard musculoskeletal protocol and with WB-CBCT using the following two radiation protocols: standard dose (CBCT-STD) and high dose (CBCT-LRG). The MDCT scans were performed on a Siemens SOMATOM Perspective (Siemens, Germany). The CBCT scans were performed on a CurveBeam AI HiRise (CurveBeam AI, Hatfield, PA, USA).

DICOM images were manually segmented by undergraduate biomedical engineering students using 3D Slicer, 3D-modeled, and superimposed to assess congruency between modalities. Mean surface distance differences relative to MDCT were calculated, with values <1.0 mm predefined as clinically acceptable.



CurveBeam AI Hirise in Hip Position

mHiRise43 Rev. A

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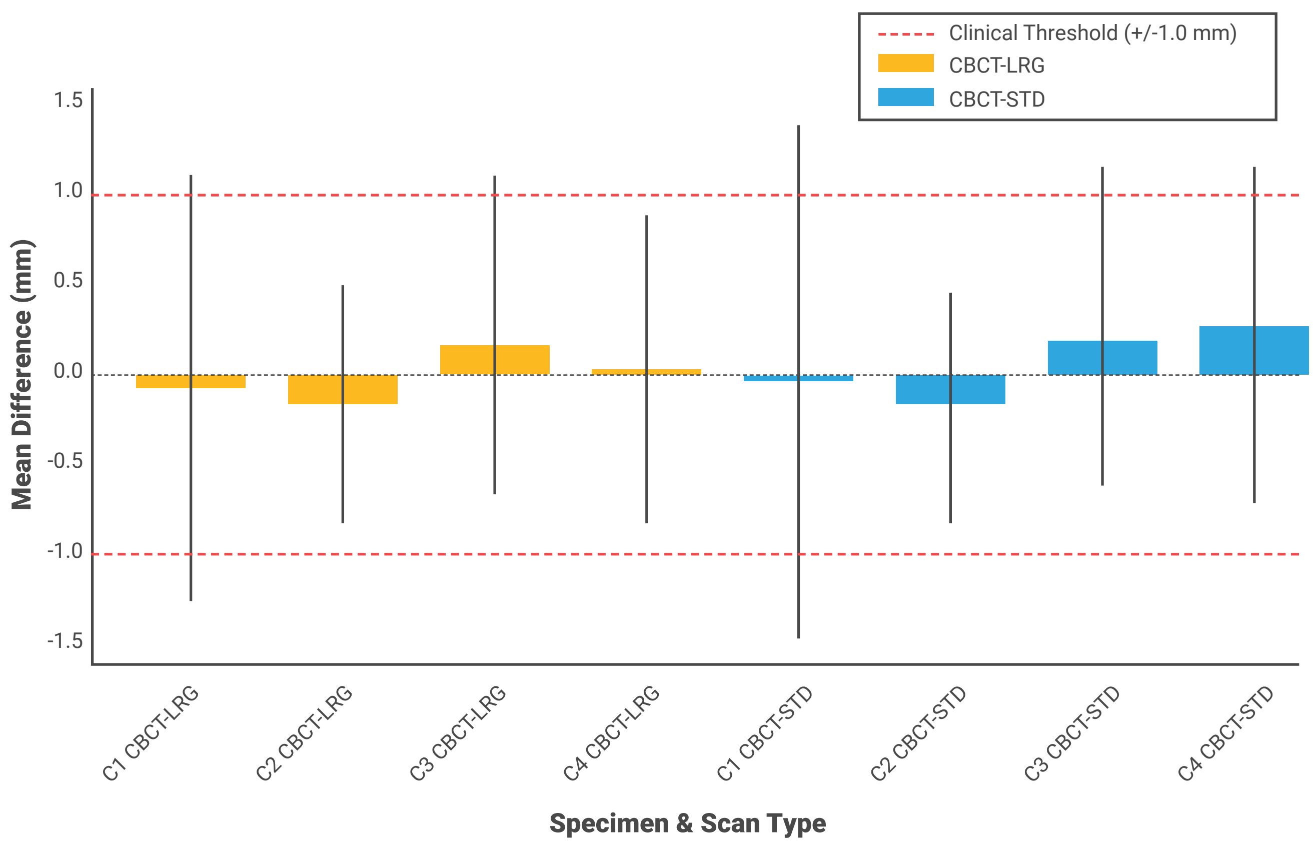
Table 1. Mean Surface Distance Differences (mm) Between WB-CBCT and MDCT

Specimen	Scan Type	Mean	Std Dev	BMI
C1	CBCT-LRG	-0.0799	1.1469	26
C1	CBCT-STD	-0.0322	1.3727	26
C2	CBCT-LRG	-0.1739	0.7294	35
C2	CBCT-STD	-0.1691	0.7059	35
C3	CBCT-LRG	0.1607	0.9914	31
C3	CBCT-STD	0.2110	0.9976	31
C4	CBCT-LRG	0.0238	0.9135	40
C4	CBCT-STD	0.3535	1.1770	40

Graph 1. Mean Surface Distance Differences (mm) Between WB-CBCT and MDCT



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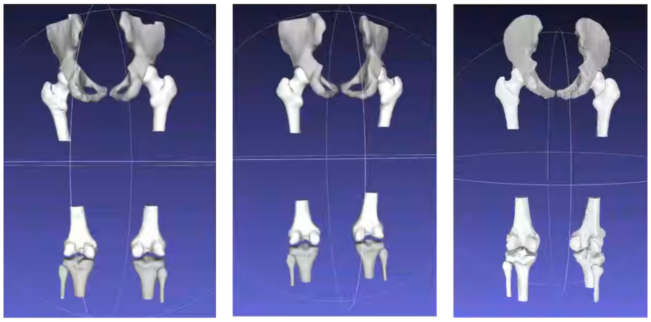
Interpretation

- For all specimens and protocols, mean differences were minimal, ranging from -0.17 to +0.35 mm.
- Standard deviations indicated good consistency across bones, with CBCT-LRG showing slightly tighter variance.
- All measurements remained well within the predefined <1.0-mm clinical acceptability threshold, confirming strong alignment with MDCT reference anatomy. (Figure 1.)
- Standard deviations were stable across all evaluated extremities and BMI levels, indicating reliable consistency in bone-model congruency.

Figure 1.



CBCT-LRG-LEFT CBCT-LRG-RIGHT CBCT-STD-LEFT CBCT-STD-RIGHT MDCT-LEFT MDCT-RIGHT

Discussion

The data demonstrates that WB-CBCT produces highly accurate bone models equivalent to MDCT, while providing distinct clinical advantages:

- **Accuracy:** All observed deviations (<0.5 mm) fall within accepted clinical thresholds, confirming CBCT's reliability for surgical planning and device design.

Discussion (cont.)

- **Radiation exposure can be safely minimized:** Both CBCT_STD and CBCT_LRG protocols produced consistently similar sub-millimeter accuracy, allowing clinicians to confidently use lower-dose settings in most patients without compromising image fidelity.
- **Weight bearing assessment:** Unlike MDCT, WB-CBCT reveals joint alignment under physiological load, providing functionally relevant anatomical information for orthopedic evaluation.
- **Considerations for high BMI patients:** While accuracy remained within clinical thresholds across all BMI categories, the highest-BMI specimen (BMI 40) showed improved variability with the higher-dose protocol, suggesting that targeted dose increases may enhance precision when imaging patients with substantial soft-tissue volume.

Conclusion

Upgraded weight bearing CBCT technology delivers accuracy comparable to MDCT while offering the added clinical value of imaging patients under physiological load. Accuracy remained stable across all BMI levels, and both standard- and large-dose protocols produced consistently high-fidelity 3D models, supporting safe dose reduction in routine use. For patients with very high BMI, selective dose adjustment may further refine geometric precision.