Purpose: A dedicated cone-beam CT (CBCT) system for musculoskeletal extremities imaging has recently been developed to complement existing technologies and provide new capabilities in weight-bearing imaging, combined planar and volumetric imaging, and improved workflow. This paper presents the first physical performance characterization of the scanner prototype in terms of imaging dose, contrast resolution, spatial resolution and image quality.

Methods: The system employs a Varian 3030+ flat-panel detector (0.194 mm pixel pitch) and a 0.875 kW fixed anode x-ray source. The scanning orbit is 220o, and the magnification factor is 1.3. Performance characterization involved measurements of HVL and imaging dose in a 16 cm CTDI phantom as a function of tube voltage (60-120 kVp) and position with respect to the scanning orbit. Contrast, noise, and line-pair resolution were investigated using a Catphan phantom. Anthropomorphic knee and hand phantoms with simulated soft tissues provided initial qualitative assessment of spatial and contrast resolution.

Results: Effective dose at the isocenter was 0.14 mSv for a nominal knee scan (90 kvp, 93.1 mAs/scan) and 0.07 mSv for a nominal hand scan (90 kVp, 49 mAs/scan), compared to 0.03-0.16 mSv in conventional CT of the extremities. The entrance surface dose for the knee varied 0.08-0.22 mSv, depending on location. Spatial resolution exceeded 15 lp/cm (0.33 mm-1) for full-resolution readout. Soft-tissue contrasts inserts in the range ~+-20 HU were readily discernable. Exquisite visualization of bone architecture and soft-tissue visibility approaching that of conventional CT was observed in anthropomorphic phantoms.

Conclusion: The prototype scanner provides high spatial resolution, volumetric images with soft-tissue resolution at doses less than or comparable to conventional CT. The capability for weight-bearing and multi-mode imaging could benefit a wide variety of musculoskeletal applications. The prototype system is being deployed in a clinical feasibility study

Funding Support, Disclosures, and Conflict of Interest:

This research was supported in collaboration with Carestream Health, Inc., Rochester, NY