Purpose:
Dual-energy (DE) imaging has the potential to transcend contrast limitations of conventional CT. We investigate DE imaging in cone-beam CT (CBCT), including exogenous iodine and gadolinium (the latter relatively novel in CT but with promise in cartilage imaging) and simultaneous imaging of multiple contrast agents.

Methods:
Experiments used a test-bench emulating a prototype extremities CBCT scanner. Nominal single-energy technique was 90 kVp + 0.3 mm Cu (~0.15 mSv). DE-CBCT involved a double-scan at low (60 kVp + 2 mm Al) and high energy (100-120 kVp + 0.5 mm Ag) (~0.6 mSv total). Projection-based and reconstruction-based decomposition were performed. Initial studies included a 16 cm cylindrical phantom (simulated soft tissue, bone, and various concentrations of iodine and Gd) and a cadaveric wrist for DE-CBCT arthrography.

Results:
DE-CBCT improved discrimination of exogenous contrast from bone, facilitating detection of articular abnormalities. Results demonstrate intravascular and/or intraarticular Gd as a viable agent for CBCT and DE-CBCT, providing significant enhancement over water at low concentrations (down to 0.78 mg/mL) and low radiation dose (~0.15 mSv). Excellent linearity of DE-CBCT voxel values was achieved but demonstrated the need for high-quality scatter correction. Simultaneous DE-CBCT of iodine and Gd yielded clear discrimination of exogenous contrast in bone-cancelled images down to 16.7 mg I/mL and 7.8 mg Gd/mL, supporting feasibility in imaging cartilage degeneration and bone marrow edema in rheumatoid applications.

Conclusions:
Results prove the feasibility of contrast-enhanced DE-CBCT, including simultaneous I/Gd discrimination in 3D arthrography. The work supports translation of DE-CBCT to clinical CT scanners as well as a dedicated CBCT for extremity imaging. Primary limitations include false enhancement from image artifacts and long scan times (20 s) on the current scanner prototype. The work suggests new opportunites for DE-CBCT in areas conventionally reserved for MRI and ultrasound – e.g., imaging of synovitis and cartilage degeneration.

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