Purpose: Cone-beam computed tomography (CBCT) is an important online imaging modality for image-guided radiotherapy and intervention. But its image quality is significantly inferior to diagnostic CT due to excessive scatters, suboptimal detector performance and approximate cone reconstruction artifact. We are developing a novel Tetrahedron Beam Computed Tomography (TBCT) system which circumvents the inherent problems of CBCT and potentially can achieve similar image quality as diagnostic CT scanners.

Method and Materials: A TBCT benchtop system has been built with a 75-pixel field emission x-ray tube. A 5-row CT detector array was built using silicon photodiodes and $CdWO_4$ scintillators. The linear source and linear detector are aligned perpendicular and parallel to rotation plane respectively. The x-ray beams are collimated to fan-shape by a group of multi-slot collimators. FDK and iterative TBCT image reconstruction algorithms were developed.

Results: Due to its scatter rejection geometry, the use of high-performance discrete x-ray detectors and iterative image reconstruction algorithm, TBCT image quality is superior to that of CBCT. Phantom scans produced excellent images without noticeable artifact.

Conclusion: A TBCT benchtop system has been successfully built. The multiple pixel field emission x-ray tube is fully functioning but a higher tube current is desired for future clinical systems. Iterative image reconstruction was able to remove approximate image reconstruction artifacts. TBCT would significantly improve online image quality. Clinical implementation of TBCT would improve precision of image-guided radiotherapy and intervention. Due to its diagnostic image quality, TBCT can also be used as mobile diagnostic CT scanners.