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Development and applicability of a quality control phantom for cone beam CT

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Abstract: Cone beam CT (CBCT) has shown to be a useful imaging modality for various dentomaxillofacial applications. However, optimization and quality control of dental CBCT devices is hampered due to the lack of an appropriate tool for image quality assessment. To investigate the application of different image quality parameters for CBCT, a prototype polymethyl methacrylate (PMMA) cylindrical phantom with inserts for image quality analysis was developed. Applicability and reproducibility of the phantom were assessed using seven CBCT devices with different scanning protocols. Image quality parameters evaluated were: CT number correlation, contrast resolution, image homogeneity and uniformity, point spread function, and metal artifacts. Deviations of repeated measurements were between 0.0% and 3.3%. Correlation coefficients of CBCT voxel values with CT numbers ranged between 0.68 and 1.00. Contrast-to-noise ratio (CNR) values were much lower for hydroxyapatite ($0 < \text{CNR} < 7.7$) than for air and aluminum ($5.0 < \text{CNR} < 32.8$). Noise values ranged between 35 and 419. The uniformity index was between 3.3% and 11.9%. Full Width at Half Maximum (FWHM) measurements varied between 0.43 mm and 1.07 mm. The increase of mean voxel values surrounding metal objects ranged between 6.7% and 43.0%. Results from preliminary analyses of the prototype quality control phantom showed its potential for routine quality assurance on CBCT. Large differences in image quality performance were seen between CBCT devices. Based on the initial evaluations, the phantom can be optimized and validated.