Purpose: The streak artifacts caused by metal implants have been recognized as a "missing data" problem that limits various applications of CT imaging, such as target delineation and accurate dose calculation. How to deal with the missing data is essential in metal artifact problems. In this work we want to investigate a method that can minimize the missing information and reconstruct images with significantly reduced metal artifacts.

Methods: A penalized-weighted-least-squares method is first used to accurately identify the metal objects in image space. Based on this prior knowledge, a new model-based scanning scheme is designed by shifting the object center during a CBCT scan to avoid the metal regions and reduce the missing projections. An iterative algorithm based on constrained optimization is then used for the image reconstruction. It minimizes a quadratic edge-preserving smoothness measure function of the image, subject to the constraint that the estimated projection data is within a specified tolerance of the available metal-shadow-excluded projection data, with image non-negativity enforced. The algorithm is evaluated using a numerical QA phantom (350x350x16, 1 mm3, only central slice considered) with simulated Poisson noise in the projections. The new scanning scheme is modified over a conventional half-fan scanning geometry with source-to-axis and source-to-detector distances of 100 cm and 150 cm, respectively. Total 339 views projection data are simulated over 360o rotation.

Results: Studies showed that the constrained optimization with the model-based scanning data has superior performance compared with analytical FDK reconstruction and other iterative reconstructions. It significantly suppressed metal artifacts in the presence of noise. Profile comparisons and RMSE measurements also suggested that the model-based scanning scheme can effectively reduce the missing information and yield better images.

Conclusions: The proposed algorithm can be used to significantly reduce metal artifacts to produce clinically acceptable image for current on-board CBCT image systems.