Purpose:
To improve the image contrast-to-noise (CNR) ratio for low-Z target MV CBCT while preserving the spatial resolution using a statistical projection noise suppression algorithm based on penalized weighted least-squares (PWLS) criterion.

Methods:
Projection images of a contrast phantom was acquired by a Varian 2100EX LINAC with a low-Z (Al) target and low energy x-ray beam (2.5 MeV) at two doses levels, 2.3 cGy for low dose and 23.1cGy for high dose, measured at the center of phantom. The projections of low-Z target MV CBCT were then processed by minimizing the penalized weighted least-squares (PWLS) objective function. The WLS term models the noise of measured projection and the penalty term enforces the smoothing constraints of the projection image. The variance of projection data was chosen as the weight for the PWLS objective function and it determined the contribution of each measurement. An anisotropic quadratic form penalty that incorporates the gradient information of projection image was used to preserve edges during noise reduction. Low-Z target MV CBCT images were reconstructed by FDK after each projection was processed by the PWLS smoothing.

Results:
Noise in low-Z target MV CBCT images was greatly suppressed after the PWLS projection smoothing, without noticeable sacrifice of the spatial resolution. Contrast-to-noise ratio (CNR) of the selected regions of interest in the PWLS processed low-Z target MV CBCT image is even higher than the corresponding high-dose image, and is 8 times higher than that of un-processed low-dose images.

Conclusions:
The CNR of low-Z target MV CBCT images was substantially improved while the spatial resolution was preserved by using PWLS projection smoothing. The PWLS projection smoothing algorithm allows low-Z target MV CBCT radiation dose reduction by a factor of 10 without compromising the quality of reconstructed images.