Purpose:Repeated use of CBCT in radiotherapy for patient setup and plan verification introduces non-negligible dose to patients. In this work, we propose a method to effectively reduce the imaging dose by incorporating previously acquired CBCT into an on-treatment CBCT reconstruction process.

Methods:Three CBCT scans were acquired using a low dose protocol, 10mA/10ms per projection view, on a CatPhan 600 phantom. The first two scans represent prior existing scans while the third scan represents an on-treatment low-dose scan. In this study, the Karhunen-Loève (KL) transform is used to consider the correlation among the on-treatment low dose CBCT and prior CBCTs in the projection domain. After the KL transform, the selected CBCT projection data are decomposed into un-correlated, ordered principle components. Then, a penalized weighted least-squares (PWLS) criterion is applied to restore each KL component. Different penalty strengths of the PWLS criterion are applied for restoring each KL component, which is inversely proportional to its corresponding KL eigenvalue. In such a way, a higher smoothing strength is applied on the component associated with a lower signal-to-noise ratio. After the inverse KL transform on the processed data, an FDK algorithm is used to reconstruct the on-treatment CBCT image.

Results:The proposed algorithm is able to suppress noise while preserving edge information. The image quality of low-dose CBCT processed using the proposed strategy is similar to that of a high-dose image, which is acquired with a protocol of 10 times dose. Furthermore, this new strategy outperforms the PWLS algorithm without considering prior information based on the noise-resolution tradeoff measure.

Conclusions:Information extracted from previously acquired CBCT can be effectively utilized to suppress noise in on-treatment low-dose CBCT. The presented strategy can significantly lower the patient CBCT radiation dose without compromising the quality of the images.