Purpose: With the frequent uses of CBCT in IGRT, the cumulative imaging dose to normal tissues may not be insignificant. A lower mAs protocol in CBCT acquisition reduces the dose, but dramatically degrades image quality due to excessive noise. The purpose of this study is to examine the effectiveness of the nonlocal means (NL-means) denoising algorithm in reducing noise while preserving details in simulated low-dose patient CBCT.

Method and Materials: NL-means algorithm estimates the true value of a pixel as a weighted average of all pixels in the image, where the weights depend on the similarity between the pixels. Compared with the local smoothing or filtering methods, NL-means can reduce noise while preserve details. Low-dose patient CBCT images were generated by adding noise to the normal-dose images based on stochastic property of incident photons from the x-ray source, simulating data acquisition with reduced mAs. The low-dose images were normalized to be within [0 1] and then fed to the NL-means for denoising. The optimal parameters for NL-means were experimentally determined.

Results: The simulated low-dose CBCT had only 6.3% of the patient CBCT dose. NL-means clearly reduced the noise without obvious blurring, and the images appear to have similar quality as normal-dose images. The suppressed noise resembled the desired white noise except at sharp edges. The mean signal-to-noise ratio in homogeneous regions was increased from 7.6 to 28.1. NL-means preserved anatomic details as fine as 2 pixels but blurred single-pixel details.

Conclusion: Results on the patient data demonstrated that NL-means effectively reduced the noise while preserving most fine details in simulated low-dose patient CBCT, consistent with results on phantom study. A single set of optimal parameters was suitable for various CBCTs. This post-processing method can be straightforwardly implemented in OBI software.