Purpose: The objective of this study is to evaluate the feasibility of proton beam treatment verification using in-room PET. As of February 2012, four patients have been studied in a clinical trial. In addition, we suggest a new method comparing the distal surface of the measured and simulated PET activities to verify the location of the distal dose surface.

Methods: Patients were scanned for 20 minutes with an in-room PET positioned next to the proton treatment head in a gantry room for beam delivery using passive scattering. The time between end of treatment and the start of the scan was within about 2 minutes. The predicted distribution of the PET activities and the proton dose distributions in the patients were also calculated using Monte Carlo (MC). Along the beam direction, the 50% fall-off positions of the maximum PET activity at each line profile were compared with the MC simulated and the measured PET images, and then the differences were assessed with root-mean-square deviation (RMSD) and mapped in the beam's eye view.

Results: The measured PET images showed a good spatial correlation with the simulated PET images and the proton dose distributions even though the treated volumes and locations varied between patients. The RMSD values, representing the surface differences between the measured and simulated PET, were assessed to be 4.3-5.1 mm for four patients. Some region including the penumbra showed larger differences but was excluded.

Conclusions: We have explored the potential of the in-room PET for proton therapy monitoring through a clinical trial. The PET image analysis method based on MC simulations showed that the distal dose surface could be determined within a few millimeters but not within the aimed accuracy of 2-3 mm. Improvements in PET-CT image registration and biological washout modeling will most likely increase the accuracy further.

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