Purpose: To quantify the benefit of adaptive fractionation, through both theoretical test cases and patient data.

Methods: We consider the effect of delivering a different fraction size based on the changes observed in the patient anatomy. Given that a fixed prescription dose must be delivered to the tumor over the course of the treatment, we find that adaptively varying the fraction size results in a lower cumulative dose to a primary organ-at-risk (OAR). We construct a one dimensional theoretical example by randomly varying the distance between the tumor and OAR, and simulate the benefit of adaptive fractionation in such a setting. Next, we test our methodology using contoured daily CT images from 5 prostate patients.

Results: For the theoretical example, we found about a 10% decrease in dose to the OAR when using a uniformly distributed motion model and a 20% daily fraction size deviation. In general, the amount of decrease in dose to the OAR varied significantly (5-85%) for these theoretical test cases depending on the amount of motion in the anatomy, the number of fractions, and the range of fraction sizes allowed. Preliminary results from the prostate patients indicate an average reduction in dose to the rectum of 1.4%, 3.5%, and 7.0% when using 20%, 50%, and 100% daily fraction size deviations, respectively.

Conclusions: Qualitatively, the theoretical example indicates that adaptive fractionation is beneficial for disease sites in which there is significant inter-fractional motion. We also expect greater benefit when using many fractions and allowing for large daily fraction size deviations. For the prostate disease site in particular, we find that adaptive fractionation is beneficial only when allowing large daily fraction size deviations. Further research quantifying the gain for disease sites that exhibit significant inter-fractional motion, such as rectal and cervical cancers, would be useful.

Funding Support, Disclosures, and Conflict of Interest:

Partially supported by Siemens.