AbstractID: 5834 Title: Real-time tumor tracking with a feedback-controlled treatment couch

Purpose: To determine the feasibility of a moving treatment couch to compensate for real-time respiration-induced 3D tumor motion observed in patients.

Methods: The couch dynamics were modeled as a critically damped second order system with dead time. The controller was modeled as a first order system to simulate the model dynamics mismatch between the couch and the controller. The feedback system was modeled as a closed-loop internal model control system and the parameters to describe the dynamics were obtained from previous feasibility studies. To determine the performance of this system, the average tumor trajectory data derived from 4D CT for 14 patients was considered. To simulate variations in normal intra-fraction respiration patterns for a given patient, distributions in amplitude and period were modeled and the residual tumor motion determined. The output of the control system was analyzed by evaluating the distribution of residual tumor motion. Furthermore, a detailed analysis of the residual motion as a function of tumor amplitude and velocity was conducted.

Results: The mean 3D amplitude of uncompensated tumor motion was 7.1 ± 4.6 mm for 14 patients. Following feedback control, the mean residual tumor motion was 0.35 ± 0.20 mm with a mean respiratory period of 4 s. The residual motion was under 3 mm for all patients, for the range of time constants investigated. The response of the couch correlated linearly with instantaneous tumor velocity for the range of parameters used to describe the system dynamics ($R^2 = 0.98$).

Conclusion: The treatment couch can be used to compensate for real-time tumor motion, given real 3D tumor trajectories.

Conflict of Interest: Supported by 3DLine Medical Systems.