AbstractID: 12750 Title: A Novel beam-specific PTV design to account for setup error and range uncertainties for scanning beam proton therapy

Purpose: Conventional PTV is purely geometric concept that is inadequate for proton therapy since it does not take into account range errors that arise from CT number uncertainties and interplay effect of setup error and tissue heterogeneity. Especially for spot-scanning proton therapy, we can't use the passively scattered proton planning approach, such as compensator smearing. This study investigates a novel method of designing PTV that guarantees adequate target coverage to CTV under such uncertainties.

Methods and Materials: The CTV was expanded laterally from the axis of beam's eye view (BEV) to account for internal organ motion and setup error. Ray tracing algorithm is used to calculate range uncertainty at distal and proximal surfaces. Due to lateral setup error and organ motion, range uncertainties were analyzed within the lateral motion breadth to construct the maximum (distal) and minimum (proximal) range surfaces along each ray line. This is equivalent to compensator smearing. Subsequently, these water-equivalent ranges were converted to physical margins using local density information along each ray line. Mathematical phantom was constructed and planned using conventional PTV and new beam-specific PTV under single field uniform dose treatment technique. Dose distributions were compared under different simulated setup error and motion.

Results: The plans using conventional PTV showed significant cold spots and hot spots in the presence of setup error and motion. The minimum percent dose of CTV coverage dropped from 96.7.9% to 38.0% when both setup error and motion is applied. However, plans using beam-specific PTV only showed minimum dose drop from 96.9% to 87.4%. The resulted dose distribution showed significant advantage in covering the edge of the CTV using beam-specific PTV.

Conclusions: This preliminary study indicates the feasibility of proton beam-specific PTV to guarantee adequate target coverage under anticipated setup error in heterogeneous human tissue.