Deformable

Preliminary investigation and application of a novel deformable PRESAGE® dosimeter

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Deformable 3D dosimeters have potential applications in validating deformable dose mapping algorithms. This study evaluates a novel deformable PRESAGE® dosimeter and its application toward validating the deformable algorithm employed by VelocityAI. The deformable PRESAGE® dosimeter exhibited a linear dose response with a sensitivity of 0.0032 ΔOD/(Gy/cm). Comparison of an experimental dosimeter irradiated with an MLC pencil beam checkerboard pattern under lateral compression up to 27% to a non-deformed control dosimeter irradiated with the same pattern verified dose tracking under deformation. CTs of the experimental dosimeter prior to and during compression were exported into VelocityAI and used to map an Eclipse dose distribution calculated on the compressed dosimeter to its original shape. A comparison between the VelocityAI dose distribution and the distribution from the dosimeter showed field displacements up to 7.3 mm and up to a 175% difference in field dimensions. These results highlight the need for validating deformable dose mapping algorithms to ensure patient safety and quality of care.

On the need for comprehensive validation of deformable image registration, investigated with a novel 3-dimensional deformable dosimeter

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Purpose To introduce and evaluate a novel deformable 3-dimensional (3D) dosimetry system (Presage-Def/Optical-CT) and its application toward investigating the accuracy of dose deformation in a commercial deformable image registration (DIR) package. Methods and Materials Presage-Def is a new dosimetry material consisting of an elastic polyurethane matrix doped with radiochromic leuco dye. Radiologic and mechanical properties were characterized using standard techniques. Dose-tracking feasibility was evaluated by comparing dose distributions between dosimeters irradiated with and without 27% lateral compression. A checkerboard plan of 5-mm square fields enabled precise measurement of true deformation using 3D dosimetry. Predicted deformation was determined from a commercial DIR algorithm. Results Presage-Def exhibited a linear dose response with sensitivity of 0.0032 OD/(Gy*cm). Mass density is 1.02 g/cm3, and effective
atomic number is within 1.5% of water over a broad (0.03-10 MeV) energy range, indicating good water-equivalence. Elastic characteristics were close to that of liver tissue, with Young's modulus of 13.5-887 kPa over a stress range of 0.233-303 kPa, and Poisson's ratio of 0.475 (SE, 0.036). The Presage-Def/Optical-CT system successfully imaged the nondeformed and deformed dose distributions, with isotropic resolution of 1 mm. Comparison with the predicted deformed 3D dose distribution identified inaccuracies in the commercial DIR algorithm. Although external contours were accurately deformed (submillimeter accuracy), volumetric dose deformation was poor. Checkerboard field positioning and dimension errors of up to 9 and 14 mm, respectively, were identified, and the 3D DIR-deformed dose passing rate was only 3%/3 mm = 60.0%. Conclusions The Presage-Def/Optical-CT system shows strong potential for comprehensive investigation of DIR algorithm accuracy. Substantial errors in a commercial DIR were found in the conditions evaluated. This work highlights the critical importance of careful validation of DIR algorithms before clinical implementation.