A virtual simulator designed for collision prevention in proton therapy.

Abstract:

In proton therapy, collisions between the patient and nozzle potentially occur because of the large nozzle structure and efforts to minimize the air gap. Thus, software was developed to predict such collisions between the nozzle and patient using treatment virtual simulation. Three-dimensional (3D) modeling of a gantry inner-floor, nozzle, and robotic-couch was performed using SolidWorks based on the manufacturer's machine data. To obtain patient body information, a 3D-scanner was utilized right before CT scanning. Using the acquired images, a 3D-image of the patient's body contour was reconstructed. The accuracy of the image was confirmed against the CT image of a humanoid phantom. The machine components and the virtual patient were combined on the treatment-room coordinate system, resulting in a virtual simulator. The simulator simulated the motion of its components such as rotation and translation of the gantry, nozzle, and couch in real scale. A collision, if any, was examined both in static and dynamic modes. The static mode assessed collisions only at fixed positions of the machine's components, while the dynamic mode operated any time a component was in motion. A collision was identified if any voxels of two components, e.g., the nozzle and the patient or couch, overlapped when calculating volume locations. The event and collision point were visualized, and collision volumes were reported. All components were successfully
assembled, and the motions were accurately controlled. The 3D-shape of the phantom agreed with CT images within a deviation of 2 mm. Collision situations were simulated within minutes, and the results were displayed and reported. The developed software will be useful in improving patient safety and clinical efficiency of proton therapy.