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Evaluation of metallic implant artefact on photon beam calculation algorithms: a study using CIRS thorax phantom

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The aim of this study was to evaluate the effect of metallic artifact on dose calculations for patients with metallic implants and to find ways in reducing the errors associated with actual dose delivered. The error magnitude in dose calculations using two different treatment planning system (TPS) algorithms and dose measurements in a CIRS (Model 002LFC) IMRT thorax phantom with a metal insert in the spine was assessed for two different CT window settings. As described in figure 1, the CIRS phantom was CT scanned using an adult thorax routine for two sets of images (i.e. Mediastinum and Osteo window settings). A 3D anterior-posterior (APPA) conformal treatment plans (using 6MV and then 15MV photon beams) was done using a typical 2 Gy to a target volume (point 5 on the CIRS phantom) with a Collapsed Cone (CC) and Pencil Beam (PB) calculation algorithms for both CT image sets. Maintaining the same parameters, the plans were recalculated using a corrected image set (overriding the metal density in the artifact region with that of water). Doses to the selected point of interest in the phantom were measured using a calibrated PTW Farmer ionization chamber TM 30010 and a PTW UNIDOS webline electrometer based on the techniques as described in IAEA TRS 398 and compared with the TPS calculations. Average discrepancies of 2.4% and 5.2% for 6MV and 4.6% and 4.5% for 15MV between calculated and measured doses were observed for collapsed cone and pencil beam algorithms respectively using the mediastinum CT window setting. For the Osteo window setting, discrepancies of 2.7% and 3.1% for 6MV and 5.0% and 2.7% for 15MV between calculated and measured doses were observed for collapsed cone and pencil beam algorithms respectively. Correcting for the metal artifact by overriding its densities in CT sets during planning gave higher average dose discrepancies of 16% for both energies. This suggests that caution should be exercised when using only corrected metal artifact CT scans for dose calculations in TPS as it only gives superior isodose coverage but not the actual dose to selected point of interest. The results as captured in table 1 of this study indicated the shortcomings of the PB algorithm and higher photon energy for the test case performed and, therefore the use of the CC algorithm and low photon energy is highly desirable. There was no statistically significant difference according to the kinds of CT window settings used. In addition, it will be necessary in the future to consider the use commercial metal artifact reduction tool for clinical routine to help avoid misinterpretation of dose distributions during planning.

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