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Development of a pelvic prosthesis phantom using 3D printing technology for the radiotherapy dosimetry of cancer patients with hip Ti prostheses

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Radiotherapy is a well-established treatment modality for pelvic lesions. Hip replacement is a surgical procedure in which the hip joint is replaced by a prosthetic implant. During irradiation of malignancies in the hip or pelvic region with external megavoltage beams, the presence of metallic prostheses complicates dosimetry and treatment delivery due to the dose perturbation effect of high-Z materials in radiation fields. This work describes a novel pelvic prosthesis phantom that was developed using 3D printing technology for studies involving the dosimetry of patients with hip Ti prostheses. The phantom is made out of water-equivalent Nylon-12 layers and is equipped with unilateral hip Ti prosthesis and the bony structures of the pelvis and lower abdomen. Dose perturbations caused by the Ti implant were studied using Gafchromic film measurements in 10 × 10 cm2 15 MeV electron and 10 MV photon beams. At the interface between tissue and metal on the beam entry side of the prosthesis, dose enhancements of about 10% and 25% were recorded for the 15 MeV and 10 MV beams, respectively. On the beam exit side of the prosthesis, the 10 MV photon beam was attenuated by 17% which would lead to a dose reduction at the target. A dosimetric error of 10⊠25% caused by prostheses could influence treatment outcome. This study shows that using 3D printing technology, very complex phantoms can be developed for the radiotherapy dosimetry of patients with metallic implants. The novelty of the presented phantom for dose perturbation studies is that it reflects clinical irradiation setups better than using simplified phantom geometries which may differ considerably from real patient cases.

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